AN ANALYTICAL STUDY OF THE POLIO ERADICATION EXPERIENCE IN INDIA, WITH SPECIAL FOCUS ON UTTAR PRADESH

Dissertation Submitted to the Jawaharlal Nehru University in Partial Fulfillment of the Requirements for the Award of Degree of

DOCTOR OF PHILOSOPHY

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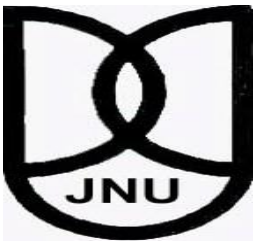

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Declaration

The thesis entitled "**An Analytical Study of the Polio Eradication Experience in India, with Special Focus on Uttar Pradesh**" is submitted for the award of the Degree of Doctor of Philosophy of Jawaharlal Nehru University. This thesis has not been submitted previously for the award of any other degree of this or any other University and is my original work.

Mshukla

Madhurima Shukla

We recommend this thesis be placed before the examiners for evaluation for the award of the degree of Doctor of Philosophy.

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CONTENTS

Acknowledgement.....iii-v

Abstract.....vi-vii

1. **The Concern**.....1-36

2. **Recognizing Polio as a Crippling Disease - *Epidemics of the Disease to its Vaccines Inventions***.....37-79

3. **Diffusion of Polio Eradication Initiative in Developing Region - *Endemic Disease to A Global Problem***.....80-159

4. **Polio Program Implementation - *Period of Unprecedented Progress***.....160-198

5. **Contextual Polio Program Challenges - *Global and Local Concerns***.....199-289

6. **Contextual Contestations of the Polio Program - *Epidemiological and Ethical Debates*** 290-327

7. **Summary and Discussion**.....328-471

Conclusion.....472-477

References.....478-489

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ABSTRACT

In industrialized developed countries today, poliomyelitis is a distant memory. Very few people would recall the epidemics of poliomyelitis and its related fears, afflicting people's lives for many years until the scientific breakthrough in developing the polio vaccines. In the western hemisphere success of the polio vaccine in the prevention of polio the disease came as a significant relief for the families and general population. Scientists' hard work for so many years was finally paid off with the discovery of polio vaccines.

After the success of the polio vaccine in epidemic-prone regions of the world, the global community looked towards endemic countries where populations did not experience the daunting fear associated with epidemics of the poliomyelitis.

After the success of the poliomyelitis program in Latin America's underdeveloped areas, a global commitment was launched in 1988 as the Global Polio Eradication Initiative (GPEI) to eradicate polio from all remaining WHO region countries. It was promised that by 2000 the world would be polio-free similar to smallpox disease. However, after years of enormous efforts and resources put in to immunize the children of the world with polio vaccine. The global promise to eradicate polio remained unfulfilled, together with problems of the resurgence of polioviruses in polio-free countries.

Based on the experience of the Latin America region, the global blueprint was provided to endemic countries in the world to follow for polio eradication. The world was ready with the polio vaccine and strategies to implement the worldwide war against

poliomyelitis diseases, particularly in the polio-endemic countries. However, many complexities lie in the way of this ambitious global health project.

The simple blueprint provided by WHO based on Latin America's successful experience in eradicating the dreadful disease was far less effective in other countries when exported from one region to other countries and other areas of the world. The National Immunization Days (NIDs) using the oral polio vaccine (OPV) as a primary strategy was ineffective in achieving the same dramatic results in other parts of the world and within countries in some specific regions. Policy innovations were necessary for governments to accomplish the goal of eliminating the poliovirus from their land.

The struggles of the GPEI program and its repeated failure were traced in this dissertation with a context-rich case study of India. Tracing the journey from identifying polio as a global health problem to the commitment for its global eradication. This dissertation provides an insight into why the global drive to extinct poliovirus faced setbacks for several years in India for over two decades in the WHO South-East Asia Region (SEARO). This research aims to critically analyse how the global polio eradication program and its strategies were adapted, institutionalized and implemented in the diverse socio-cultural milieu of India marked by unequal regional and socio-economic development. The study reconstructs the history of the polio eradication program in India using analytical analysis to describe what happened with the polio eradication program in the Indian setting and explains why it was the case. This dissertation contributes to global health policy scholarship. The policy scope of this research work is that it documents how an international health program interacts with contextual epidemiological, environmental, and social-cultural felt needs of communities in socio-economically less developed regions.

1. THE CONCERN

1.1 Background

The concept of eradication emerged in the early twentieth century. Eradication during this period was understood from zero disease incidences to extinction of the pathogen in humans and the environment.[1]

The world public health community initiated several eradication initiatives. Except for one, all other eradication campaigns were unsuccessful. Pan American Health Organization (PAHO) launched a yellow fever eradication campaign in the early twentieth century; however, the program was unsuccessful because of an animal reservoir for the yellow fever virus. Then World Health Organization, in the mid- twentieth century, started a campaign to eradicate malaria and smallpox. The malaria eradication failed, but the successful smallpox eradication campaign in 1980 marked a milestone in the history of eradication initiatives.[2]

Two international meetings discussed the concept of eradication –'Workshop on Eradication of Infectious Diseases' held in Dahlem, Germany from 16th to 22th of March in 1977 and a conference on 'Global Disease Elimination and Eradication as Public Health Strategies' held in Atlanta city of USA from 23th to 25th of February in 1988.[3]

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[1] Arita, I., Wickett, J., & Nakane, M. (2004). Eradication of Infectious Diseases: Its Concept, Then and Now. *Journal of Infectious Diseases*, 57, 1-6; Stepan, N.L. (2011). *Eradication: Ridding the World of Diseases Forever?*. New York: Cornell University Press.

[2] Stepan, N.L. (2011). *Eradication: Ridding the World of Diseases Forever?*. New York: Cornell University Press; Arita, I., Wickett, J., & Nakane, M. (2004). Eradication of Infectious Diseases: Its Concept, Then and Now. *Journal of Infectious Diseases*, 57, 1-6

[3] Aylward, R.B., Hull, H.F., Cochi, S.L., Sutter, R.W., Olive, J.M., & Melgaard, B. (2000). Disease eradication as a public health strategy: a case study of poliomyelitis eradication. *Bulletin of the World Health Organization*, 78(3); Dowdle, R.W. (1998). The principles of disease elimination and eradication. *Bulletin of the world health organization*, 76(2),22-25.

The Dahlem workshop focused on science and principles of eradication, stating not only the biological criteria as necessary for considering a disease for eradication. But also economic, societal and political considerations and its benefits.[4]

Dahlem's workshop discussed the hierarchy of public health interventions efforts for infectious diseases, which follows elimination and eradication of disease as outcomes of disease control efforts, pg. 6[5] -

Control: The reduction of disease incidence, prevalence, morbidity or mortality to a locally acceptable level due to deliberate efforts. Continued intervention measures are required to maintain the reduction.

Elimination of disease: Reduction to zero of the incidences of a specified condition in a defined geographical area due to deliberate efforts. Continued intervention measures are required.

Elimination of infection: Reduction to zero of the incidences of disease caused by a specific agent in a defined geographical area due to deliberate efforts. Continued measures to prevent the re-establishment of transmission are required. Example: measles and poliomyelitis.

Eradication: Permanent reduction to zero of the worldwide incidences of infection caused by a specific agent due to deliberate efforts. Intervention measures are no longer needed.

Extinction: The specific infectious agent no longer exists in nature or the laboratory.

[4] Dowdle, R.W. (1998). The principles of disease elimination and eradication. *Bulletin of the world health organization*, 76(2),22-25.

[5] Dowdle, R.W. (1998). The principles of disease elimination and eradication. *Bulletin of the world health organization*, 76(2),22-25.

Based on the above definition success of the smallpox eradication program in 1980 is considered a milestone in the history of public health. The program accomplished the goal of complete disease extinction and became the first disease to be eradicated by global efforts.

The program's success was attributed to many biological, political, and economic factors. There was no animal reservoir of the virus, and patients did not transmit the virus after recovery, so immunization of the human population effectively stopped transmission. The vaccine was effective in promoting immunity in vaccine recipients against smallpox. Surveillance of disease transmission was successful as the disease had visible distinctive clinical features and did not have subclinical infections of epidemiological importance. Above all, the smallpox eradication program was implemented under the strong leadership of the World Health Organization (WHO) with continuous cooperation for funding and operational logistics from WHO member states. The success of smallpox eradication strengthens the concept of eradication (as the extinction of causative pathogen in both the human population and environment). It builds hope among the international community for the possibility of eradicating other diseases.[6]

The smallpox eradication campaign showed that the concept of eradication not only involves a biological rationale for eradicating disease but humanitarian benefits and economic costs as well. Eradication as public health strategy involves large-scale global effort, massive funding, time and labour to eradicate a disease. Thus, eradication has been debated and

[6]Donald, A. H. (2011). The eradication of smallpox – An overview of the past, present, and future. *Vaccine,* 29S, D7– D9; Bhattacharya, S., & Dasgupta, R. (2009) A Tale of two global health programs smallpox eradication's lessons for the Antipolo campaign in India. *American Journal of Public Health*, 99(7); Arita, I., Wickett, J., & Nakane, M. (2004). Eradication of Infectious Diseases: Its Concept, Then and Now. *Journal of Infectious Diseases*, 57, 1-6.

questioned as the public health strategy to be adopted for defining the strategies of disease programs and their overall benefits to humans and society.

After smallpox the following disease selected by WHO for its complete eradication was Poliomyelitis. The Forty-First World Health Assembly passed the resolution to eradicate polio by 2000. It was the twentieth century when epidemics of poliomyelitis in western industrialized developed countries became a consistent problem. Fear of their children getting polio infection and transforming it into paralytic polio in a short period was nerve-breaking for families. Uncertainty in scientific explanations of disease treatment and cure was significant concern among the general public. The acute fear of disease among people pushed the scientists to not only find a treatment for polio. But also defeat the disease through a medical technological tool – *a vaccine*. The determination of scientists on this devastating paralyzing disease led to the discovery of first inactivated (killed) inject-table polio vaccine (IPV) by Dr Jonas Salk and later live attenuated (weakened) oral polio vaccine (OPV) was developed by Dr Albert Sabin. In 1955 United States (US) accepted Salk's vaccine as the first polio vaccine and was used to immunize children against the disease. Later in 1961 US changed the vaccine and started using Sabin's OPV for a fight against the poliovirus. It was the Soviet Union countries which laid the foundation for polio eradication using the OPV. Much of the evidence on the safety and efficacy of the oral polio vaccine came from large field trials in Russia and Eastern European countries.

Largescale nationwide mass immunization campaigns covering the entire population eliminated the poliovirus in Czechoslovakia in 1960. Czechoslovakia was the first country in the world to eradicate the much-feared disease. Later, Cuba, a Latin American country, adopted and implemented the same approach and became the second polio-free country after Czechoslovakia.

The United States joined the list of polioviruses eliminated countries almost seventeen years after Cuba in 1979. Both vaccines were widely used in western developed countries to control the poliovirus, resulting in a decline in disease incidence. But also, the elimination of poliovirus from their land.

The Pan American Health Organization (PAHO), motivated by the success in other countries and in the United States, decided to implement universal immunization campaigns using OPV as National Immunization Days (NIDs) and expanded the program in all the countries of the Latin American region. In 1985, the PAHO became the first region in the world to decide on eradicating poliomyelitis from the entire area by the year 1990. The success came to the PAHO region one year later, in 1991 becoming polio-free.

The safety and efficacy of OPV and strategies for eradicating polio using large polio vaccination campaigns in endemic tropical regions of the world with varied climatic and socio-economic conditions came from Latin America region. The successful strategies used in Latin American countries provided a blueprint for the global eradication of polio disease and confidence for its worldwide use, mainly in developing and under-developed areas.

The success of smallpox eradication in 1980 and the elimination of poliovirus in Latin American countries motivated the international community to take poliomyelitis as the following disease for eradication. The Forty-First World Health Assembly (WHA) in 1988 passed the resolution to eradicate polio by the year 2000 and its certification by 2005. Global Polio Eradication Initiative (GPEI) was launched as part of the WHA resolution to complete the eradication goal.

The resolution was supported by massive investments and the pooling of funds from donors worldwide. The war against the poliomyelitis disease started across the other WHO

regions. Countries were motivated to join the global fight against the poliovirus for the concern of their country's children and to avoid disability. It was possible to protect the children against the paralytic polio and envisage a polio-free world. As the oral polio vaccine and its program strategies were considered effective. Within a decade, almost all the countries in the world adopted the polio eradication goal and started implementing NIDs using OPV. The success of eradicating the second disease - Poliomyelitis- was not too far away. However, the global polio eradication program did not unfold as visioned by international organizations in other parts of the world.

Certificate

World Health Organization
South-East Asia Region

REGIONAL COMMISSION FOR CERTIFICATION OF POLIOMYELITIS ERADICATION

The Commission concludes, from the evidence provided by the National Certification Committees of the 11 Member States, that the transmission of indigenous wild poliovirus has been interrupted in all countries of the Region. The Commission declares today, 27 March 2014, that the South-East Asia Region is poliomyelitis-free.

Dr Suparnit Chunsuttiwat
Chairperson

Dr Suniti Acharya

Prof. Anthony Adams

Prof. Tariq Iqbal Bhutta

Dr Abraham Joseph

Prof. Ismoedijanto Moedjito

Prof. Mahmudur Rahman

Prof. David Salisbury

Dr Kyaw Myint Sein

Dr Kinzang Tshering

Dr Nalini Withana

New Delhi, 27 March 2014

On 26–27th March, 2014 seventh meeting of the South-East Asia Regional Certification Commission for Polio-Eradication (SEA-RCCPE) was held in New Delhi, India. The meeting was not just a regular meeting to assess each country's progress towards the polio eradication goal. Nevertheless, it was a historic day for South-East Asia Region (SEARO), particularly for India as a member of the SEARO WHO region.

During the event, the Chairperson, Dr Supamit Chunsuttiwat, said -

"Based on a thorough review of the national documentation on polio eradication provided by the national certification committees of the countries of this region, this Commission concludes that WPV transmission has been interrupted in the WHO South-East Asia Region. It is, therefore, my pleasure and honour to declare, on behalf of the South-East Asia Regional Certification Commission for Polio Eradication, that on this day, Thursday, March 27 2014, the South-East Asia Region is free from WPV transmission." pg.16[7]

On this day historic ceremony had taken, and a certificate of regional certification of polio eradication signed by all its members was presented to SEARO Director, Dr Poonam Khetrapal Singh. Dr Singh acknowledged the contributions made towards this success not only by the leadership of national governments and support of international donors. But also, by front-line workers in making the region polio-free.

In 1988 when WHA resolution for polio eradication was taken, the South-East Asia Region was the one of the significant priorities for poliovirus elimination with its largest population. The burden of polio was considered to be very high due to vast underreporting.

The eleven countries of the WHO-SEARO started implementing National Immunization Days (NIDs - mass polio immunization campaigns) in the mid-1990s. After years of intensive efforts, no cases of wild poliovirus were reported in 2012. It was incredible progress toward polio eradication in the WHO-SEARO as it joined the other three polio-free regions of WHO – Region of America declared polio-free in 1994, the Western Pacific Region in 2000 and the European Region in 2002.

[7] World Health Organization. (2014). *South-East Asia Regional Certification Commission for Polio Eradication (SEA-RCCPE), Seventh* Meeting. WHO Regional Office for South-East Asia. (Retrieved from www.polioeradication.org)

It was incredible progress toward polio eradication in a region where more than 20 per cent of the world population lives. However, this success came after more than two decades of struggles to eliminate the poliovirus in the region. However, most SEARO countries reported their last polio case by 2000. Excluding Bhutan, Maldives and Sri Lanka where reported last case was even before mid1990s. India was the last country in the entire region struggling to successfully interrupt the indigenous wild poliovirus transmission. India was the last country in the entire region struggling to interrupt the indigenous wild poliovirus transmission successfully. The last case of polio (type 1) was reported on January 13, 2011 in a two-year-old girl from Howrah District, near Kolkata, West Bengal. Since 2011 there was no reported case of wild poliovirus transmission in the India. After three consecutive years of absence of wild poliovirus in the entire region was declared free by the regional polio certification committee. Thus, WHO certified SEARO (including 11 countries) polio-free after a long wait on March 27th, 2014.

Although India became a signatory of the World Health Assembly 1988 resolution on polio eradication. It was not until 1996 that India started the NIDs. In 1979 when the polio vaccine was launched, it was delivered under the routine immunization system of the Universal Immunization Program (UIP) (till 1990, immunization program was called Expanded Program on Immunization (EPI)). It was in 1995 that India launched its pilot study on NIDs using oral polio vaccine (OPV), and the following year started the national wide Pulse Polio Immunization (PPI) program as part of the Global Polio Eradication Initiative (GEPI) goal. The polio eradication program was implemented under four-point strategies using routine immunization and NIDs for delivering OPV, mop-up campaigns to eliminate remaining poliovirus and an established surveillance system to identify gaps and measure success towards interrupting poliovirus.

India's success story of polio eradication is a story of many challenges and failures to interrupt the poliovirus. The program's success in India was seen internationally as the most significant public health success. India's success was huge because it was the last country with its second-largest population in the whole SEARO consistently missed the deadline to eliminate the poliovirus. India was delaying the progress of the entire SEARO region. India occasionally imported poliovirus to other polio-free countries within the SEARO region and globally and one of the significant risks for other polio-free SEARO countries. The deadline to eliminate the polio virus was revised several times in India from 2000 to 2002 to 2007.

Since 2011 there has been no reported case of wild poliovirus transmission in the country. India took almost two decades to interrupt poliovirus transmission compared to other countries in the region that had already achieved the global target by 2000. This research work understands the story of GPEI and its experience in the Indian context. It answers why India became a global threat to achieving the goal of global polio eradication as the only country remaining in SEARO to interrupt the poliovirus transmission.

1.2 Research Concern

The world health assembly's resolution to eradicate polio from the planet generated the international momentum to eliminate the second disease after smallpox success. After the global commitment to eradicate polio was made, efforts to adopt the Latin America polio model were accelerated dramatically from 1988 to 2000 particularly in polio endemic developing countries. Within a short period, the global goal of polio eradication was adapted from WHO region to region and countries to countries within the regions.

The developing countries adopted the GEPI goal of eradicating poliovirus and implemented the successful poliomyelitis program strategies tested in Latin American.

However, the program strategies repeatedly failed, particularly in the underdeveloped and developing regions. Struggles in the GPEI program are evident from the Sixty-Fifth World Health Assembly (WHA) 2012 resolution.

"URGES the Member States with poliovirus transmission to declare such transmission to be a "national public health emergency", making poliovirus eradication a national priority programme, requiring the development and full implementation of emergency action plans to be updated every six months until poliovirus transmission has been interrupted. pg. 2"[8]

In 2011 both Independent Monitoring Board of the GPEI, in its report and Strategic Advisory Group of Experts on Immunization meeting in the same year, stated that polio cannot be eradicated and needs to be given the highest priority to finishing the goal of eradication. The expert committees unequivocally requested the World Health Assembly declare polio transmission a global public health emergency.[9]

World Health Assembly, in its resolution, appealed to the world's countries to respond to polio as a global emergency and the highest political priority to vaccinate all children. The health assembly requested its members to engage at all levels to address the risk of failure to eradication through continued problem of resurgence of polio through importation and circulating vaccine derived poliovirus and maintain highest population immunity.[10]

Coincidentally one year before the WHA resolution India reported its last polio case and was successfully able to interrupt poliovirus transmission in the next year with no polio cases reported. The success of India was historic worldwide because the country's progress

[8] World Health Organization (2012) *Poliomyelitis: intensification of the global eradication initiative, Sixty-Fifth World Health Assembly*. Geneva, WHA 65.5. (Retrieved from www.who.int)

[9] World Health Organization (2012) Polio eradication. *Weekly Epidemiological Record*, 87(1),1–16. (Retrieved from www.who.int);World Health Organization (2012) *Poliomyelitis: intensification of the global eradication initiative, Sixty-Fifth World Health Assembly*. Geneva, WHA 65.5. (Retrieved from www.who.int)

[10] World Health Organization (2012) *Poliomyelitis: intensification of the global eradication initiative, Sixty-Fifth World Health Assembly*. Geneva, WHA 65.5. (Retrieved from www.who.int)

towards eradication goal was holding the other SEARO countries to get certified with the status of the polio-free country despite reporting the last polio case by the year 2000. India's success came after a long struggle to effectively implement the global eradication strategies promoted by WHO based on the Latin American experience. India continued for almost two decades to interrupt poliovirus transmission, particularly in the country's northern parts. The context-specific implementation challenges India experienced were not only operational to vaccinating the last child in the country. But it was also related to epidemiological limitations of OPV, resulting in its poor efficacy in some states of northern India. India achieved historic success only after including new strategic innovations in implementing the polio immunization campaigns.

The persistent failure of domestic governments and the overall GPEI campaign are reflected in the WHA 2012 declaration. The simple blueprint provided by WHO based on Latin America's successful experience in eradicating the dreaded disease was far less effective in other countries. The successful elimination of poliovirus in most of the western world countries and parts of developing regions in Latin America was used as evidence by WHO to promote the goal of polio eradication by 2000. However, the national immunization days (NIDs) using the OPV as a primary strategy was ineffective in achieving the same dramatic results in other parts of the world and within the countries in some specific regions. Policy innovation was necessary for governments to accomplish the goal of eliminating the poliovirus from their land.

Within the above context, this research explores the complexities that lie in the way to this ambitious global health project – to eradicate the polio disease. The struggles of the GPEI program and its repeated failure are traced with a context-rich case study of India. Tracing the journey from identifying polio as a global health problem to the goal commitment for its global eradication. This research work provides insight into why the global drive to extinct poliovirus

faced setbacks for the South Asia region, particularly in India as the only country remaining for several years to eliminate poliovirus successfully.

The research work examines international polio policy diffusion in South Asia. It explains the historical and political factors which made polio (after smallpox) to be chosen as the second disease over other highly predominant infectious diseases such as measles for global eradication. The research work focusing on developing countries covers the period after 1970s when polio became a public health problem to developing countries. Until the 1970s, the problem of polio was a significant problem for many western countries. However, it was relatively insignificant for the developing countries dealing with other diseases. Based on the experience of the Latin America region, the global blueprint was provided to the rest of the countries to follow for polio eradication. However, this global blueprint was far less effective in developing countries when simply exported from one region to other countries and other regions of the world. The polio eradication policy innovations diffusion, adaptation, institutionalization, and implementation met with persistent failures in India, a country within the northern region.

This research aims to critically analyse how the global polio eradication program and its strategies are adapted, institutionalized and implemented in the diverse socio-cultural milieu of India marked by unequal regional and socio-economic development. The study reconstructs the history of the polio eradication program in India using analytical analysis to describe what happened with the polio eradication program in the Indian setting and explain why it was the case.

At the global level, the research traces the global history of polio eradication initiatives from the pre-vaccination period to the formation of GPEI as an international collaborative

global effort to eradicate poliovirus globally. The study examines the success of eradicating poliovirus in the American region and its influence on the formulation of GPEI and its eradication strategies. At the country level, the study documents the experiences of diffusion, adaptation and implementation of the polio eradication program within the Indian setting.

Primarily the research critically examines the implementation of polio eradication strategies in one of the socio-culturally and economically disadvantageous and challenging states of Uttar Pradesh (UP) in the northern region of India. Implementing the polio eradication program was difficult in the largest democracy of India. The poor performance of the program and its repeated failure in the northern states of Uttar Pradesh resulted in missing the global deadline to eradicate polio several times in India. Thus, India's eradication strategies changed several times as per the region's epidemiological, environmental and socio-cultural needs to eliminate poliovirus.

Focusing on the state of UP, the study examines specifically questions of spatial variability and environmental determinants of polio endemicity within the state, socio-cultural and political determinants obstructing the acceptance of polio vaccines among the community, and state-specific changes made to the polio immunization program implementation strategies for achieving the success of polio eradication program within the state of UP.

1.3 Rationale of the Study

The global polio eradication program has taken about three decades and is still in its end-stage. It has been marked in India as a success in most parts and technical and social challenges in others. Till 2013 with the last case of polio, India remained one of the four endemic countries in the world & Uttar Pradesh was the endemic area from where the infection was exported within and outside the countries.

There has been much criticism of the decision to eradicate polio as well as on some of its strategic components raised among others serious public health ethical questions. As the polio end game strategy phase remains in operation, some uncertainty still prevails till final global eradication certification. At the national level, it is considered by the most of the public health expert's second-largest achievement after the smallpox eradication program.

In the past decades, the success and failure of the program as a consequence of its strategies were, to a more considerable extent, in the state of Uttar Pradesh (UP) centric. The state UP provides a contrast where districts in western UP reported a high number of polio cases compared to other southern-central districts. Western UP districts became an endemic reservoir of poliovirus. It is therefore essential to deconstruct the experiences of the polio eradication program in Uttar Pradesh.

1.4 Research Gap & Policy Scope of the Study

Polio eradication was the next public health endeavour after smallpox eradication to eradicate poliovirus from human society. Thus, the GPEI gained massive popularity, and there is no shortage of literature published on the polio eradication initiative and its experiences in WHO members countries. Much of the literature documenting challenges and success stories of polio eradication programs in countries was funded by partner donors, international social development agencies, scientists, other polio experts, and people involved with GPEI. Positive narratives dominate the enormous literature published on polio eradication about the program implementation experiences in countries without providing much insight into the unbiased, critical analysis of the context-specific debates and discourses on problems and challenges encountered by the program implementers and the communities. The GEPI literature sees the problem of polio and its eradication program through the frame of biomedical, epidemiological and public health paradigms. The GPEI literature broadly discusses two themes as part of polio

policy analysis -1) relevance of polio as the international public health priority and its success stories, and 2) concerns and debates on GPEI and its strategies used in endemic regions.

Focusing on this research gap, the research is conducted independently by the researcher without any involvement with GPEI activities. The research work is among the few studies contributing to a non-biased understanding of the struggles of GPEI and its experience in India.

It also contributes to understanding the implications of the polio eradication program experiences in India for other remaining polio-endemic countries. This research work not only discusses weaknesses in the content of the policy. But it also addresses the research gap on how the polio policy unfolded in the country within the environment of epidemiological, socio-cultural, and political contestations and document policy-related processes and implementation of the polio program in India.

This research contributes to global health policy scholarship. The policy scope of this research work is that it documents how an international health program interacts with contextual epidemiological, environmental and social-cultural felt needs of communities in socio-economically less developed regions. It re-emphasizes the importance of acknowledging the contextual socio-cultural, economic and political determinants in global health governance for ensuring global health equity. Particularly for improving the international health practice in low- and middle-income countries. India is committed to eliminating tuberculosis, malaria, and measles. The findings from the research will contribute to identifying future policy research questions for better implementation of disease elimination programs.

1.5 Research Questions

This research work investigates broadly three research questions.

1) What were the contextual historical, socio-cultural, political and economic factors at the global level under which the Global Polio Eradication Initiative (GPEI) and its strategies for polio eradication evolved?

2) What were contextual and implementation level experiences of polio eradication strategies in the Indian context?

3) How & why did Uttar Pradesh state within the northern region of India become a global and local concern for achieving the eradication goal?

1.6 Conceptual Framework for Analytical Analysis of Polio Eradication Policy & its Strategies

1.6.1 Concept of Policy Analysis

The policy generally arises because of dissatisfaction with certain conditions among public or interest groups or because of political-economic forces and represents what ought to be done.[11]

Policy analysis is interdisciplinary subject drawing concepts, tools and methods for analysis from various other disciplines such as sociology, history, economics, politics, science, and public administration. It is multi-method and multi-disciplinary and focuses on the policy process. The terms policy definition, framework and methodologies used in policy science are

[11] Walt, G. (1994) *Health Policy: An Introduction to Process and Power*. Zed Books, London; Barker, C. (1996). *The Health Care Policy Process*. London: Sage Publications.

derived from different schools of thought and ideologies defining the differentiation in the policy process and underlying social relationships assumptions.[12]

Among the various definitions of policy, the most used definition is given by Pressman and Wildavsky, who describe policy (1973) as a "hypothesis containing initial conditions and predicted consequences".[13]

Gill Walt 1994 defines

"Health policy embraces courses of action that affect the set of institutions, organizations, services, and funding arrangements of the health care systems. It goes beyond health services, however, and includes actions and intended actions by the public, private and voluntary organizations that impact health*"* pg.41[14]

Policy analysis involves two approaches- first approach is *analysis for policy*, this includes analysis of provision of technical and economic information for policy making, monitoring, and evaluation. The second approach is *analysis of policy* which focuses on analysis of processes and values affecting origins, intentions, construction, and conduct of policies.[15]

Policy analysis research studies can be conceptualized at three levels called layers of policy analysis- international level (international actors influencing health policy); national level (power influences policy-nature of political system and extent of participation), and actual

[12] Walt, G. (1994) *Health Policy: An Introduction to Process and Power*. Zed Books, London; Walt, G, and Gilson, L. (1994). Reforming the Health Sector in Developing Countries: The central role of policy analysis. *Health Policy and Planning*, 9(4), 353-370; Barker, C. (1996). *The Health Care Policy Process*. London: Sage Publications.

[13] Hill, M. (1993). *The Policy Process: A Reader*. Harvester Wheatsheaf. London.

[14] Walt, G. (1994) *Health Policy: An Introduction to Process and Power*. Zed Books, London

[15] Walt, G. (1994) *Health Policy: An Introduction to Process and Power*. Zed Books, London; Barker, C. (1996). *The Health Care Policy Process*. London: Sage Publications.

processes of policy and actors involved at each stage of policy formulation, implementation and evaluation.[16]

There are two models which define the policy-making process. A rational model defines policy-making as rational decision-making of policy choices logically to achieve the best policy option. It prescribes how policy ought to be made. Analysis for policy focuses on the rational model. The second model is incrementalist, which criticizes the analytical model linear stage approach of policy making and describes the way policy is made or what is happening in the policy-making process and how different interest groups and actors influence the policy making. The incrementalist model focuses on the analysis of policy.[17]

This research study analyses the polio eradication program in India and uses an incrementalist model. The study focuses on the last layer of polio policy analysis to understand the actual processes of policy and actors in implementing the polio eradication program in India.

1.6.2 Framework for Policy Analysis

This study uses Gill Walt's 1994 policy analysis framework for polio eradication. The analytical framework uses a political economy approach for health policy analysis and can be used retrospectively and prospectively. The framework incorporates context, process, actors, and policy content as essential elements for policy analysis. It represents a complex set of interrelationships among the four elements and is not considered the framework of separate components. The framework stresses the significance of complex social, political and

[16] Walt, G. (1994) *Health Policy: An Introduction to Process and Power*. Zed Books, London.

[17] Walt, G. (1994) *Health Policy: An Introduction to Process and Power*. Zed Books, London.

economic interactions, including values systems within which the policy is formulated and implemented. This study critically analyses the policy-related processes and changes in policy during the formulation and implementation of the polio eradication program in India by focusing on the context, processes, actors, and policy content.

1.6.3 Rationale for Using the Above Framework

Literature on the polio eradication program focuses primarily on the criticism of the program and its content. The polio eradication policy was an international agenda driven by international cooperation, so 'what' the endemic countries should do to eradicate the disease was clearly defined and known.

However, it is less comprehensively documented on how countries carry out the polio eradication, what were the processes, who were the actors involved in the policy and how and what were the factors involved in its effective implementation. International organizations and policymakers assumed that the success of polio policy in other developed countries would be easily replicated in developing countries such as India. Still, various socio-cultural-economic factors delayed the effective implementation of the program. The focus on the epidemiological relevance for developing countries and flaws in the content of the polio eradication program in GPEI literature neglects the study of other essential dimensions of eradication program analysis comprising of processes, actors and context and influence of all these elements on policy choices and its practical implementation.

Thus, using the above framework to critically analyse and reconstruct the historical trajectory of the unfolding polio eradication policy in the country throughout the formulation and implementation of the program. The study will look at the social, economic, and political-cultural context within which the polio policy was formulated and executed; policy processes

associated with development and implementation; the role of various actors and interest groups involved in policy making; and interactions between all of them. The performance of the polio program will be studied based on political, technical, and managerial factors and resources.

1.6.4 Conceptual Definition of Elements of the Framework

The below section explains the conceptual meaning of elements of the policy framework used in this study for policy analysis, data collection, interpretation and representation of data.

Policy Content – Content of the health policy answer the '*what'* of policy and reflects the context, process and actors involved in policy-making.[18]

Policy Context – The context in policy analysis is the health policy environment in which the policies are formulated and implemented. The context comprises macro-level social, political and economic factors at the international and national level and micro-level community, household and individual characteristics. The health policy environment can be influenced by contextual factors such as instability or uncertainty created by changes in political regime or war; historical experiences; climatic changes such as disasters; the nature of the political and economic system of a country; the dominance of one type of ideologies and values such as neo-liberal or socialist ideology; culture factors of the society such as nature of hierarchies, religious system, and ethnic, linguistic, religious differences; international factors influencing

[18] Walt, G. (1994) *Health Policy: An Introduction to Process and Power*. Zed Books, London; Buse, K., Mays, N. & Walt, G. (2005). *Making Health Policy*. New York: Open University Press.

sovereignty and requiring international cooperation in health. These factors influence health policy formulation and policy outcomes.[19]

Contextually the policy environment of the global polio eradication campaign is influenced by three events- the success of smallpox eradication, polio eradication initiative in the American region and in other developed countries, and the global approach taken for public health programmes with the retreat of primary health care approach in 1979 and rise of selective primary health care approach. The polio eradication program in India was influenced by the international policy environment. The program was not based on epidemiological criteria but on the feasibility of eradicating the disease. The polio eradication program involved massive cooperation from international organizations. The success in eliminating the poliovirus was dependent on other countries as the virus can be imported from endemic countries.

Process – The process in policy analysis answers the '*how'* of policy development and implementation. The policy-making processes explain how policies are initiated, developed or formulated, negotiated, communicated, implemented and evaluated.[20] It describes agenda setting, decision making and implementation of policy changes.[21]

[19] Walt, G. (1994) *Health Policy: An Introduction to Process and Power*. Zed Books, London; Buse, K., Mays, N. & Walt, G. (2005). *Making Health Policy*. New York: Open University Press.

[20] Buse, K., Mays, N. & Walt, G. (2005). *Making Health Policy*. New York: Open University Press.

[21] Walt, G. (1994) *Health Policy: An Introduction to Process and Power*. Zed Books, London; Buse, K., Mays, N. & Walt, G. (2005). *Making Health Policy*. New York: Open University Press.

The policy processes are generally understood through the stage approach in policy making. There are four stages/phases discussed in policy literature which define policy making process[22] –

- **Problem Identification and Issue Recognition**- This stage explores how issues get onto the policy agenda and why some other problems are not addressed.
- **Policy Formulation**- This stage explores how policies are formed and focuses on actors involved in formulating policy, discussion, negotiation, agreement, and how they are communicated.
- **Policy Implementation** is the most essential and often neglected stage of policy making. The stage explores the reasons for the non-implementation of policy, changes, and factors involved in implementing policy and its effect on excepted policy outcome.
- **Policy Evaluation**- In this stage, policy actions after implementation are evaluated in terms of monitoring, achieved objectives and unintended implications. The policy can be changed or terminated at this stage, and a new approach can be introduced.

Thus, the processes of policy-making provide analysis of processes involved in agenda settings-how issues get on to the policy agenda; how policy is formulated on the subject; the influence of actors and their power, values and interests involved in agenda-setting and policy-making; decision-making processes in policy; implementation; and evaluation of policy.[23]

Actors- In the policy analysis, actors define the '*who'* makes and implements policy decisions. The policy choices and implementation practices are influenced by the actors involved in

[22] Walt, G. (1994) *Health Policy: An Introduction to Process and Power*. Zed Books, London; Buse, K., Mays, N. & Walt, G. (2005). *Making Health Policy*. New York: Open University Press; Barker, C. (1996). *The Health Care Policy Process*. London: Sage Publications.

[23] Buse, K., Mays, N. & Walt, G. (2005). *Making Health Policy*. New York: Open University Press.

policy-making. The actors in the policy analysis framework are at the core of policy analysis and have their inter-linkages with the context and processes of policy. Actors can be individuals, members of interest groups, and professional associations/organizations at the international, national, and sub-national levels. They are influenced by the context within which they live, work and make decisions at macro governances. Micro-institutional-level processes in policy-making at local, national, regional or international levels are influenced by the actors, their position in the power structure and their values, interests, and expectations.[24]

The key determinant in policy-making, changes, and implementation is a group of actors involved in policy-making. There are many actors in the policy process, such as politicians, state or government and their ministries, such as the ministry of health; international multilateral and bilateral organizations, funding organizations, private sector, bureaucrats, medical professionals and associations, media, pressure and interest groups, civil society and non-government organizations, religious organizations, community health workers, public or people who get affected by policy change consisting of individuals, members of households and community members.[25]

The extent of the influence of actors on the policy process and its decision-making is understood through the concept of power. The actors and their power are dominant in the policy-making process.

In policy-making, some individuals and groups have more power than others. Thus, decision-making in policy is not a rational process but involves the power struggles between competing

[24]Walt, G. (1994) *Health Policy: An Introduction to Process and Power*. Zed Books, London; Buse, K., Mays, N. & Walt, G. (2005). *Making Health Policy*. New York: Open University Press; Walt, G, and Gilson, L. (1994). Reforming the Health Sector in Developing Countries: The central role of policy analysis. *Health Policy and Planning*, 9(4), 353-370.

[25] Buse, K., Mays, N. & Walt, G. (2005). *Making Health Policy*. New York: Open University Press.

groups.[26] The power and powerlessness of some groups over others influence the understanding of an issue, agenda-setting, decision-making choice of solutions and its implementation, and its expected outcome.

The actors derive power from a set of attributes: individual wealth, personality, level of or access to knowledge, or authority. However, these attributes and the extent of actors' power strongly influenced organizations and structures, including networks within which actors live and work. Thus, in policy-making, it is essential to understand the nature, distribution and manner of exercising power by the actors involved in policy-making and its implementation.[27]

Policy Implementation- The program implementation is part of the policy-making process and answers the '*how'* of policy. It reflects on how the policy formulated is executed and the achievement of its expected policy outcomes.

Studying policy implementation is essential to policy analysis studies but is often neglected in policy literature. Thus, policy implementation analysis is less researched in health policy studies.[28] Policy research uses two theoretical perspectives to study implementation-top-down and bottom-up approaches. Both define the way implementation is understood in policy studies.[29]

Early theoretical policy studies focus on policy-making as a linear sequential process with a clear division between policy formulation and policy implementation called a top-down

[26] Buse, K., Mays, N. & Walt, G. (2005). *Making Health Policy*. New York: Open University Press.

[27] Buse, K., Mays, N. & Walt, G. (2005). *Making Health Policy*. New York: Open University Press.

[28] Walt, G. (1994) *Health Policy: An Introduction to Process and Power*. Zed Books, London.

[29] Walt, G. (1994) *Health Policy: An Introduction to Process and Power*. Zed Books, London; Brinkerhoff, D.W. (1996). Process Perspective on Policy Change: Highlighting Implementation. *World Development*, 24(9), 1395-1399.

approach. The top-down approach comes from the rational model of the policy-making process. Linear stage understanding of policy process involves- formulation, implementation, evaluation, and termination. Policy formulation involves political processes, values, and judgment and defines as "what ought to be done". Policy implementation follows policy formulation automatically and is defined as the more technical process and managerial or administrative activity.[30]

The top-down approach is derived from the ideal model of perfect implementation by Hogwood and Gunn (1984), which involves a set of elements for successful implementation - adequate time and sufficient resources availability, availability of the right combination of resources at each stage, minimal dependency relationships, policy based on the valid theory of cause and effect, the direct relationship between cause and effect, agreement on objectives, fully specified tasks conducted in the correct sequence, perfect co-ordination, perfect compliance, and that external circumstances do not impose severe constraints. The top-down approach is critiqued as policy-driven, hierarchal, and concerned with effectiveness and control, focusing on policy goals to be achieved by implementers.[31]

The bottom-up approach to policy analysis is derived from inductive implementation studies. Implementation from the bottom-up approach is considered a complex activity and one of the missing links in the study of social policy. In the bottom-up approach both formulation of policy and its implementation are in a continuous loop and both these elements are should

[30] Brinkerhoff, D.W. (1996). Process Perspective on Policy Change: Highlighting Implementation. *World Development*, 24(9), 1395-1399; Walt, G. (1994) *Health Policy: An Introduction to Process and Power*. Zed Books, London; Buse, K., Mays, N. & Walt, G. (2005). *Making Health Policy*. New York: Open University Press.

[31] Brinkerhoff, D.W. (1996). Process Perspective on Policy Change: Highlighting Implementation. *World Development*, 24(9), 1395-1399; Walt, G. (1994) *Health Policy: An Introduction to Process and Power*. Zed Books, London.

also be analysed from political perspectives.[32] Implementation in the bottom-up approach does not follow policy formulation and is considered an interactive and dynamic process characterized by negotiation and conflict.[33] The bottom-up approach does not start with policy makers' objectives, and studies extend of implementation but start with local implementers and interaction between bureaucrats and clients at the street level.[34] Implementation and implementers often play an essential part in the policy process, and its performance informs policy upwards. Research studies show that policy is often altered/challenged by actions of local implementers' decisions and by political and socio-economic environment conditions as policies and programmes adjust to local political and socio-economic environments. Thus, organization and inter-organization factors transformed policy at the implementation level. However, this approach excludes the perspectives and participation of affected clients, patients, and families.[35]

In this study, the implementation of the polio eradication program will be studied at the national, state and district levels based on political, technical, and managerial processes and resources. The study will be inductive, involving integrative macro and micro-level analysis. Thus, this study sees polio program implementation as not only technical and managerial but also influenced by the factors that impede the implementation of centrally determined policies at the ground level. The focus on performance in this study analyses the characteristics and gaps influencing the intended implementation of program change and how it informs the policy learning upwards. The analysis of polio eradication in India in this study is limited to 2014,

[32] Walt, G. (1994) *Health Policy: An Introduction to Process and Power*. Zed Books, London.

[33]Walt, G. (1994) *Health Policy: An Introduction to Process and Power*. Zed Books, London.

[34] Walt, G. (1994) *Health Policy: An Introduction to Process and Power*. Zed Books, London.

[35] Walt, G. (1994) *Health Policy: An Introduction to Process and Power*. Zed Books, London: Brinkerhoff, D.W. (1996). Process Perspective on Policy Change: Highlighting Implementation. *World Development*, 24(9), 1395-1399; Buse, K., Mays, N. & Walt, G. (2005). *Making Health Policy*. New York: Open University Press.

when WHO certified South-East Asia Region (11 Countries including India) polio-free. Post-polio elimination period in 2014 will be studied very briefly to analyze the overall post-polio experience in India and its implications.

Figure 1[36]

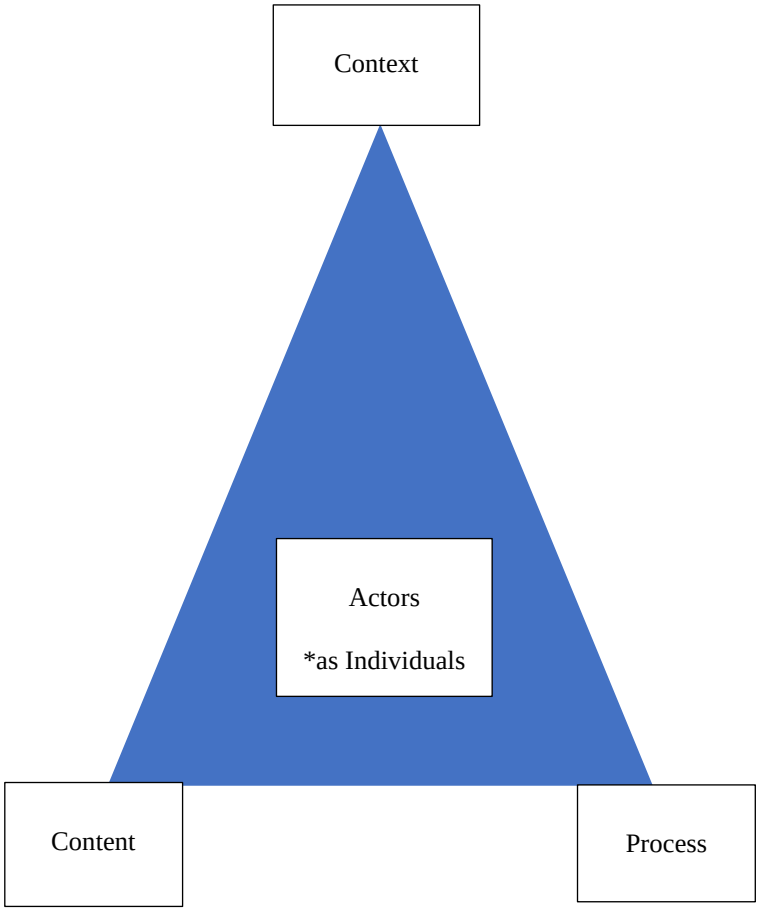

Figure 1. Framework of policy analysis adapted from Walt (1994) and Walt and Gilson (1994)

[36] Walt, G. (1994) *Health Policy: An Introduction to Process and Power*. Zed Books, London; Walt, G, and Gilson, L. (1994). Reforming the Health Sector in Developing Countries: The central role of policy analysis. *Health Policy and Planning*, 9(4), 353-370.

1.7 Research Methodology

1.7.1 Methods

The struggles of the GPEI program and its repeated failure were traced with a context-rich case study of India using a multi-method approach. The study employed two methods - document analysis and key informants' interviews. Field work for this dissertation was conducted at two sites in India and the United States of America (USA) to collect documents for data analysis both online and hard copies and for conducting interviews.

1.7.2 Sources of Data

In this study, after an extensive search, a large database was built consisting of important documents focusing on tracing the sequential events unfolding the polio eradication program story. Starting from pre vaccination era to post vaccination period when the GPEI emerged and was adapted and implemented in countries. This process helped in analyzing the historical, political, and socio-cultural factors related to unfolding of poliomyelitis as a disease to it becoming as global public health problem and experiences of its eradication.

None of the data sources used in the study stood out as primary as the goal was to analyze information from all sources to present a story of unfolding the polio eradication program globally and in India. For this study, data was gathered and researched from five sources of information –

- **First,** compilation and analysis of a database of documents produced for the Indian government by people directly involved or indirectly with program implementation. These include program strategy documents, technical reports, operational guidelines, minutes of meetings reports of annual Indian Expert Advisory Group (IEAG) meetings, (Acute Flaccid Paralysis) AFP Alerts.

- **Second,** analyses of external evaluation reports written for the Indian government and external studies and reports of the polio program's evaluation and on vaccination in general in India produced by donor agencies, partner organization in implementation, studies, papers and books by scholars', scientists' and people involved at national and global directly or indirectly with program. It also includes newspaper articles and analyses pieces authored by news agencies and program implementors.
- **Third,** grouped and analyzed documents produced at the international level for the global GPEI project and vaccination in general. These include GPEI strategic plan report, annual GPEI report, monitoring and evaluation report, technical documents, weekly epidemiological record on polio, morbidity and mortality weekly report (MMWR) by Centers for Disease Control & Prevention, GPEI Financial reports; technical consultative group (TCG) of WHO-SERO, grant documents, South-East Asia Regional Certification Commission (SEA-RCCPE) and Global Certification Commission for Polio Eradication, declarations and resolutions of World Health Assembly, annual report of WHO director and addresses.
- **Fourth,** to understand the historical roots and evolution of GPEI, extensive search and use of international conference proceedings, newspapers, books, journal articles, research studies, declarations and resolutions of World Health Assembly, WHO director reports and addresses, policy & technical documents and reports by WHO, reports by international agencies, and books and reports by partner agencies. Apart from these sources, for historical analysis of polio primary research work was done at Yale University library to collect evaluation reports, studies and books.
- **Fifth** was the semi-structured interviews using a checklist with key policymakers and program implementers in India and with other people not directly involved with the program, international agencies members, foreign scholars and scientists directly and

not directly involved with GPEI. The purpose of in-depth interviews is to triangulate the data and fill information gaps from other sources

1.7.3 Process of Collecting Data

Many of the government and program documents had restrictions and were not accessible. So, databases from online sources were used most. Some data sources were available online and accessible using the PubMed & Google Scholar search engines. An extensive search was also done using the websites and databases of international organizations, partner agencies & Indian government. For documents not accessible online extensive use of online internet archive tool was made to gather ancient documents from the websites of the Indian government and partner agencies. Also, a comprehensive search was done at Yale University library for online and hard copies of data sources not accessible in India.

Throughout the dissertation, the researcher conducted nearly 20 hours of interviews with key people. The number of people interviews conducted is limited due to the historical nature of the research. Many people involved with the program at global and national are either not alive or retired, so they are untraceable, and others were unwilling to speak for interviews. Thus, additionally, researchers have used interviews published online in newspapers, articles and websites.

The study participants for semi-structured interviews were selected based on non-probabilistic purposive sampling & snowball or chain sampling. The non-probabilistic sample helped the select researcher participants purposively based on the objectives of the study & snowball sampling supported the selection of additional participants.

Participants for semi-structured interviews were included based on the following criteria- 1) Availability & willingness to participate in the study; 2) Involvement in polio

eradication program planning & implementation and research activities for an extended period; 3) Participants refusing to participate in the study were excluded.

The potential participants' contact information was gathered. This information was collected from publicly available sources over the internet and later on through the snowball sampling method. A tentative list of participants involved in planning, implementation, and research activities of the polio eradication program is prepared through publicly available polio policy, technical and evaluation documents, research and working papers, and internet searching of government websites. Later on, through snowball sampling, other potential study participants were contacted. Potential participants were contacted via emailing the participants of the study, telephoning the participants and by visiting of the participant's office and/or area of work with the request of participation in the study. Potential participants who agreed to give consent for the study, a semi-structure interview was be conducted through emailing interview questionnaire to participants, online video calls, and by in-person visits to the participant's office and area of work. The participants in the study generally understand, read, and speak English. The interviews conducted with the participants were stored in audio-taped.

1.7.4 Ethical Consideration

The project was initiated after full approval from the Institutional Ethics Review Board at the Jawaharlal Nehru University of New Delhi, India (IERB-JNU). During this research work, I was part of the Fox International Fellowship Program at the Whitney and Betty MacMillan Center for International and Area Studies, Yale University, the USA, from August 2018 to May 2019. I also got approval from the IRB at Yale University to continue the research project at Yale University and collect data in the US. Right of study participants, confidentiality

and anonymity of data collected were maintained as per the IRB rules throughout the dissertation period, including data storage and using the analysed data for thesis writing.

Participants who were interviewed for the study were provided with the research information sheet containing all the information about the study and a consent document stating their right to participation. For the process of consent for this study, the participants were informed about the study verbally and answered all the questions related to the study and participation. Participants were told that the research was a part of the doctoral study. They were given a brief introduction of the study, its objective & usage of data collected. The participants were briefed that their participation in this study is voluntary, and they have the right to withdraw or refuse at any time from this study without giving a reason. They may decline to answer any of the interview questions. They can refuse to have an audio-taping made of the interview. The setting of consent was a natural setting during the fieldwork of the study. The participants were asked for permission to participate in the study. To maintain confidentiality and anonymity, no names of participants interviewed, terms of the affiliated organization and other details related to participants are used in the writing of this dissertation.

1.8 Chapters

The dissertation is divided into Seven Chapters –

Chapter One introduces the research study, discusses the concept of eradication as a public health strategy, explains the research problem undertaken, the conceptualization of research, the methodology adopted for analysis and the organization of chapters.

Chapter Two, using historical analyses, documents how poliomyelitis was recognized as a crippling disease in the history of public health after frequent epidemics of poliomyelitis in many of the western developed countries. This chapter revisits the history of poliomyelitis disease to understand the contemporary challenges of its eradication program. The history of

poliomyelitis has two parts – 1) history of recognizing the polio disease as a crippling disease, 2) history of finding its cure – the polio vaccine. Chapter two traces the historical journey of recognizing poliomyelitis as a crippling disease from the pre-historic era to the twentieth century. It describes the reasons for not considering polio a significant public health problem until the nineteenth century. The chapter examines how poliomyelitis epidemics in the twentieth century made poliomyelitis disease of identifiable characteristic and established it as a significant public health problem in European and American countries. The chapter towards the end examines the history of poliomyelitis in America, where a significant breakthrough was achieved with the discovery of two polio vaccines.

Chapter Three documents the history of the formation of the global polio eradication initiative. It also examines the diffusion of oral polio vaccine and global eradication strategies in developing countries, including India. Chapter examines the process of adoption and adaptation of the polio eradication policy idea. It traces the journey of the polio disease becoming a global priority for eradication. The chapter covers the period after the 1970s when polio became a public health problem in developing countries to 1995, when India launched its national pulse polio immunization program (PPI). The chapter examines debates at the global level and within the developing region, which advanced the idea of polio eradication and its successful adaptation in developing areas. The chapter uses process tracing at global, regional and national levels to uncover the external and domestic factors that influenced the cross-national diffusion of polio eradication concept from developed region to developing region. Towards the end, the chapter introduces the processes and domestic factors which diffused the idea of eradication in the South East Asia Region (SEARO) and within the region of India. It examines how the national level polio eradication program was conceptualized within the Indian context.

Chapters Four & Five document polio eradication's adaptation and implementation experiences in the Indian context. The chapter examines the implementation phase of the policy process after the adaptation of the program. It describes how a given public health program and its strategies were adapt to a country's context. It covers the period from 1996, when the pulse polio immunization program (PPI) was implemented at the national level in India, to 2014, when the South-East Asia Region (SEARO) was certified by WHO as "polio-free". The core policy debate in this chapter is focused on the tensions between global strategies used for polio eradication and their limited impact on a country's contextual environment. Using year-wise analysis, both the chapters examine what happed to the program when attempts to administer it was made at the state, district and block level focusing on the adaptation and institutionalization process. It highlights implementation constraints experienced in one of the northern states (Uttar Pradesh) that impeded the progress of the PPI program in the whole country. The slow progress in this state of India became a global concern for the success of the eradication program in the whole WHO SEARO.

Focusing mainly on the state of Uttar Pradesh, the chapter critically analyses the factors which made the state a global and national challenge for achieving the goal of polio eradication. It examines the contentions between program priority and implementation miscalculation and subsequently changes incorporated to tackle the implementation gaps. These changes shaped the overall practical policy implementation efforts and contributed to India's achieving polio-free status in 2014.

Chapter Six examines the contextual debates and concerns raised on the idea of polio eradication. Contrary to the success of the polio immunization program in endemic countries, intense contestations were raised throughout the conceptualization and implementation of the polio eradication program globally and in India by larger interest groups outside of

government. Public health experts, academicians, and scientists extensively discussed the GPEI and its strategies. These groups of communities repetitively raised doubts and questioned the overall relevance of the program and effectiveness of program strategies, particularly in resolving the problem of endemic regions. It is contested that the international community pushed GPEI as a policy priority, and the program was continued despite severe flaws in strategies used in the endemic areas. It also neglected ethical considerations in the planning and implementation of the program. The polio immunization program in India primarily evolved and was implemented within this environment of intense policy contestations. This chapter discusses the various debates and discourses on epidemiological and ethical contestations raised on the overall program and its strategies as pointed out by larger interest groups outside of government within India and globally.

Chapter Seven summarizes and discusses the key findings from the study according to the research questions.

2. RECOGNIZING POLIO AS A CRIPPLING DISEASE

Epidemics of the Disease to its Vaccines Inventions

2.1 Epidemiology of Poliomyelitis in the Contemporary Era

Poliomyelitis disease is a member of the enterovirus subgroup, family Picornaviridae. The enterovirus is a transitory inhabitant of the gastrointestinal tract. Poliomyelitis is an acute viral disease caused by three types of polio virus's serotypes-type 1,2,3. Immunity to one serotype does not provide a significant exemption from the other two serotypes. Humans are the only reservoir of poliovirus. The incubation period for non-paralytic poliomyelitis is 3-6 days and 7-21 days for paralytic poliomyelitis. The poliovirus is highly infected in children. Children are more susceptible with seroconversion rates among exposed household contacts of 100 per cent, whereas, in adults, it is greater than 90 per cent.[37]

The mode of communication of the poliovirus is through close contact with an infected person. The most common primary route of transmission is the faecal-oral route. The virus enters via the mouth into the alimentary tract, similar to diseases of cholera and typhoid. The oral-oral course is another mode of transmission. The virus spreads through droplets from the pharynx. The transmission route in any region depends on the degree of sanitation and hygiene in a population. Droplet spread is a more common transmission route in older people with a high sanitation standard.[38]

The primary site of the virus multiplication is the pharynx and gastrointestinal tract. Thus, the poliovirus is usually present in the throat and stool before infecting an individual.

[37] Estivariz, C. F., Link-Gelles, Ruth., & Shimabukuro, T. (nd.). Poliomyelitis. (Retrieved from www.cdc.gov/)

[38]Estivariz, C. F., Link-Gelles, Ruth., & Shimabukuro, T. (nd.). Poliomyelitis. (Retrieved from www.cdc.gov/)

Even after one week of onset of polio infection in an individual less virus is present in the throat. At the same time, they continue to be excreted in the faecal for several weeks. The polio infection is significantly subclinical and asymptomatic. The estimated ratio of in-apparent to paralytic polio falls in the range of 850:1. Poliovirus saliently circulates in the community transmitting to others without being recognized. The polio virus is reported through stool samples. There are three types of clinically presented poliomyelitis- abortive, non-paralytic, and paralytic.[39]

The virus causes paralytic poliomyelitis by entering from local lymphoid tissue into the bloodstream and then into the central nervous system. The virus infects cells of the nervous system and replicates, causing paralytic poliomyelitis. Paralytic poliomyelitis is paralysis of the lower limbs, including all other muscle groups of the body. The incubation period is the 1st to 10th day of significant major illness. The paralytic polio is recoverable, with cases regaining muscle power over eighteen months. After this period, paralysis becomes permanent. Paralytic polio is fatal in 2 per cent of children and 1per cent of adults.[40]

2.2 Recognizing Poliomyelitis as a Disease

The above contemporary epidemiological definition and understanding of poliomyelitis as a disease entity as we know it today is based on substantial research conducted in the pre-vaccination era to understand the disease epidemiology and its cure.

[39] Estivariz, C. F., Link-Gelles, Ruth., & Shimabukuro, T. (nd.). Poliomyelitis. (Retrieved from www.cdc.gov/); Trevelyan, B, Raynor, S.M, & Cliff, D.A. (2005). The Spatial Dynamics of Poliomyelitis in the United States: From Epidemic Emergence to Vaccine-Induced Retreat, 1910-1971. *Annals of the Association of American Geographers*, 95(2), 269-293.

[40] Estivariz, C. F., Link-Gelles, Ruth., & Shimabukuro, T. (nd.). Poliomyelitis. (Retrieved from www.cdc.gov/); Trevelyan, B, Raynor, S.M, & Cliff, D.A. (2005). The Spatial Dynamics of Poliomyelitis in the United States: From Epidemic Emergence to Vaccine-Induced Retreat, 1910-1971. *Annals of the Association of American Geographers*, 95(2), 269-293.

History is made up of images and by few people who had distinctive ideas which they followed diligently. Poliomyelitis as a disease has a historical picture of a paralyzed child with a withered limb. This is a distinct feature of poliomyelitis, where a healthy child, after fever, experiences a sudden appearance of paralysis, which is sometimes permanent. It is reasonable to assume that in the history of poliomyelitis, "the crippling nature" image should have gotten enormous attention of the physicians to understand and treat the disease. However, for a very long time, the paralysis in children after the fever was considered something caused by an evil dispelled. Paralysis was taken as an inexplicable occurrence in few children suffering from fevers .[41] The road to naming 'the crippling symptoms" as "Poliomyelitis" and defining it as "Acute Flaccid Paralysis (AFP)" was not easy, and it took many centuries.

Few scientists' efforts and substantial research directed the progress in understanding poliomyelitis's nature. However, the knowledge about the disease proceeded in a prolonged manner. The crippling illness struggled to get attention for a very long time. It became clinically apparent as a significant public health problem only after the frequent occurrences of epidemics in the twentieth century in developed western countries, mainly in Europe and America.

2.3 Struggles to Get Attention Until Epidemics

Lack of attention to the crippling disease gives an impression that it may be a disease that does not exist or that its occurrence was sporadic before epidemics in the twentieth century. However, the seeds of this crippling disease are evident in written history, pointing toward its primordial existence. Historical traces of the crippling disease are found in ancient

[41] Paul, J, R. (1971). *A history of Poliomyelitis, Yale studies in the history and medicine.* New Haven and London: Yale University Press.

archaeological evidence.[42] One of the prominent pictures in the written record is of an Egyptian man in eighteen dynasty (dating 580-1350 BC). It is of significant historical evidence indicating the occurrence of the crippling disease in infants in ancient times as interpreted by physicians.[43]

However, it is the only picture highlighting the polio-like crippling disease in the ancient period. Despite this, there are no doubts about the historical and medical diagnosis of the disease from this single picture. The image provides sufficient evidence to assure that sporadic polio cases in infants were prevalent in the ancient period.[44] Evidence of sporadic cases of paralysis of one or both legs at infancy in children was observed in ancient times in Greece and Rome.[45] Using observation as a diagnosis method, Hippocrates observed the acquired clubfoot[46] deformities in children early during his travel through Greece and Asia. This started the beginning of the scientific understanding of 'the crippling disease' as opposed to supernatural or magical explanations in the previous era.[47]

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[42] There are archeological evidences of skeletons with deformities description similar to polio paralysis cases in ancient times

[43] This medical interpretation of the picture done by Danish Physician Ove hamburger depicts a young man crippled with deformities characteristics similar to cause after infantile poliomyelitis The picture depicts a young man apparently a priest who has a withered and shortened left leg with his foot held in the typical position characteristics of flaccid paralysis. Medical interpretation of the picture was examined by several physicians more than half-century since its publication and there was a general consensus on its correct diagnosis (Paul, J, R. (1971). *A history of Poliomyelitis, Yale studies in the history and medicine.* New Haven and London: Yale University Press)

[44] Paul, J, R. (1971). *A history of Poliomyelitis, Yale studies in the history and medicine.* New Haven and London: Yale University Press.

[45] In the dark and Middle Ages physicians mostly relied on writing of Greek and Roman period for knowledge on diseases rather than observing disease cases. So, no major contribution in understanding poliomyelitis as a disease was done by physician of this period. (Paul, J, R. (1971). *A history of Poliomyelitis, Yale studies in the history and medicine.* New Haven and London: Yale University Press)

[46] Clubfoot can be congenital or acquired clubfoot.

[47] Hippocrates description of clubfoot are considered accurate as he not only observed theses deformities but also acquired treatment and cure experiences. Galen followed the footprints of Hippocrates some 500 years in Asia and in Rome and observed similar deformities in children. (Paul, J, R. (1971). *A history of Poliomyelitis, Yale studies in the history and medicine.* New Haven and London: Yale University Press)

This historical evidence was sufficient to indicate that sporadic polio disease cases were not rare before the twentieth century. However, for a very long period, it remained clinically inapparent and lacked the attention of the physicians.

In much of the sixteen, seventeen and eighteenth centuries, sporadic polio cases occurred in Europe and America. Fevers with no apparent reason and not accompanied by any visible symptoms on skin or inflammation of body parts were considered common fevers. Some childhood fevers after teething and foul bowls caused lameness and paralysis. Such lameness caused by fevers was deemed inevitable and acceptable in some children. This medical understanding of the disease was built within a crude environment where the accurate diagnosis of the disease was considered trivial by physicians. Expect for some important diseases of epidemic nature.[48]

The medical climate of the seventeenth century and most of the eighteenth century in Europe and England did not gave importance to precision in diagnosing trivial diseases. For the practicing physician, treating illness was considered an essential part of their practice for their patients than accurate diagnosis and giving names to the disorders. In this prevailing negative attitude of resistance to precision in diagnosis, sporadic polio cases were majorly unnoticed by physicians.[49]

The sporadic nature of polio disease also prevented an accurate diagnosis of the illness. The symptoms of teething and foul bowls were recognized as associated with paralysis. Difficulties in diagnosis were encountered because fevers in children were usually reported to

[48] Paul, J, R. (1971). *A history of Poliomyelitis, Yale studies in the history and medicine.* New Haven and London: Yale University Press.

[49] Paul, J, R. (1971). *A history of Poliomyelitis, Yale studies in the history and medicine.* New Haven and London: Yale University Press.

the doctors by parents after the occurrence of lameness symptoms in children. This prevented establishing a correlation between disease symptoms and lameness signs in sick children. This gap in accurate medical diagnosis was identified, and a correlation between the signs and symptoms was established later in the eighteenth century.[50]

Seventeenth and much of the eighteenth century lacked sufficient medical evidence on diagnosing polio disease and its treatment. The orthodox medical environment delayed accurate clinical diagnosis for a more extended period. However, few physicians disagreed with this prevalent traditional medical convention. The enthusiasm of few physicians of the eighteenth century, despite the crude notions against accurate diagnosis, gave the crippling disease a distinct clinical identity. These physicians used the clinical observation method to diagnose sudden attacks of paralysis among infants after fever.[51]

In 1789 first clinical description of the crippling disease was written in a medical text named "Diseases of Children" The polio disease was called "debility of the lower extremities" in the book.[52] Some physicians even proposed classifying the crippling illness as a separate entity, which was largely not an acceptable activity in the eighteenth-century medical environment.[53] Although, the clinical identification of polio disease was established in the

[50] Paul, J, R. (1971). *A history of Poliomyelitis, Yale studies in the history and medicine.* New Haven and London: Yale University Press.

[51] Paul, J, R. (1971). *A history of Poliomyelitis, Yale studies in the history and medicine.* New Haven and London: Yale University Press.

[52] A London physician name Michael Underwood was likely the first physician to recognize the relationship between fever and onset of lameness and considered polio as an entity. In his book "Diseases of Children" second edition (1793) as "debility" and fourth edition (1799) as "palsy" he gave a vivid clinical picture of poliomyelitis. In text book he wrote that the disease is more a common disorder in infants and young children not noticed by any medical writer before. The disease arises from debility and sudden attack in children who had previously fever in infantile age group of one or more than four to five years of age. (Paul, J, R. (1971). *A history of Poliomyelitis, Yale studies in the history and medicine.* New Haven and London: Yale University Press.)

[53] Thomas Sydenham (1624 -89) a London practitioner (sometimes considered as first modern clinician sometimes as father of epidemiology) his clinical judgement emphasis on classification of diseases. She

eighteenth century. There were only isolated examples of physicians who took an interest in studying the sudden occurrence of paralysis in children. Thus, the exact cause of the paralysis in infants remained broadly not understood.

It took many years for poliomyelitis to be identified as a clinical disease. It took many years for poliomyelitis to get clinical recognition in the medical discipline.[54] It is not that the disease was not noticed by a physician in Europe and America from 1793 to 1820. The sporadic polio cases in infants were noticed, but much discussion did not take place in the medical environment where medical communication among physicians was poor. After almost forty to fifty years, the disease was not recognized in the medical circles.[55]

In the nineteenth century, medical writers started describing the illness of poliomyelitis. A detailed and accurate clinical description of the disease from onset of symptoms to later residual effects was given. First recognition of its flaccid nature of paralysis was in the early nineteenth century.[56] The contribution made by many medical writers in describing the clinical features of diseases during the first half of the nineteenth century added to give a complete

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reintroduced Hippocrates observation methods forgotten two thousand years ago. Using clinical observation methods, she correlates between symptoms and sings of disease in sick patients. This paved the path for developed of a system of enumeration of disease and a system of classification and nomenclature a century later by France scholars in Scandavian, Germany and England. (Paul, J, R. (1971). *A history of Poliomyelitis, Yale studies in the history and medicine.* New Haven and London: Yale University Press)

[54] Disease was not referred in the none of the thirteen classifications of illness published between 1793 and 1818. The nomenclature of polio as "debility of lower extremities" was vague and didn't talk much about the cause of the disease. The word paralysis was associated in the list of diseases to mention only anatomical parts involve such as paralysis of one limb or two paralyses of one side of the body. There was no mention of age groups afflicted and differences in cause of paralysis. (Paul, J, R. (1971). *A history of Poliomyelitis, Yale studies in the history and medicine.* New Haven and London: Yale University Press)

[55] Paul, J, R. (1971). *A history of Poliomyelitis, Yale studies in the history and medicine.* New Haven and London: Yale University Press.

[56] The Italian physicians and surgeon Giovanni Battista Monteggia (1762- 1815) gave a vivid account of polio which was more detailed than Underwood. He didn't mention of teething as a possible cause but still his observation about the illness were vague to identify actual cause of disease. Teething as possible cause. (Paul, J, R. (1971). *A history of Poliomyelitis, Yale studies in the history and medicine.* New Haven and London: Yale University Press)

clinical picture of polio. One of the significant breakthroughs was knowing that it was the anterior spinal cord in humans where the polio attack affecting the motor nerves causing paralysis. This remarkable finding became the milestone point for understanding the disease in the coming centuries.

German orthopaedist Jakob von Heine did one of the historical landmark studies on poliomyelitis in 1840. It was the first-ever scientific study conducted on fourteen juvenile polio cases. Heine gave a complete clinical picture of poliomyelitis disease development – from its early stages to its progress to paralysis limbs, followed by long-term care and improvements in recovering patients. This clinical picture of polio disease was used in years to come as a long-lasting clinical picture of poliomyelitis. After fifty or more years, it began to take a recognizable shape. One of the significant findings from his work in 1860 was that symptoms point to an affliction of the central nervous system, namely the spinal cord. Heine's work gave poliomyelitis recognition as a separate disease entity – infantile spinal paralysis, separating from other forms of paralysis. Despite this complete clinic knowledge of poliomyelitis, understanding the illness's nature proceeded slowly.[57]

2.4 Epidemics of Poliomyelitis

The general picture by the mid-nineteenth century of poliomyelitis was that poliomyelitis was not considered a medical problem of great significance. By the mid-nineteenth century, although there was much evidence on the pathology of the disease, the epidemiological nature of the disease remained unexplored. Poliomyelitis is a disease that was not considered a contagion and infectious disease. This was because the concepts of contagion

[57] Paul, J, R. (1971). *A history of Poliomyelitis, Yale studies in the history and medicine.* New Haven and London: Yale University Press.

and infection were not fully developed in the medical environment of the eighteenth and early nineteenth centuries. As the climate was already overwhelmed with many diseases, there was not much scope for nascent ideas of contagion and infection to fully develop. It remained difficult to define and differentiate any disease as contagion and infectious. [58]

In this environment, many clustering's of cases of paralysis in infants at a particular time and place were generally unnoticed and not categorized as outbreaks. It was not until the mid- nineteenth century that physicians began reporting small clustering of polio cases co-occurring. Thus, before the nineteenth century epidemic nature of the diseases was uncommon and unknown. It was not until 1836 that scattered outbreaks of clinically identified paralysis in infancy were reported in a group of children. A few physicians noticed and observed the clustering of cases of paralysis in communities. Three small outbreaks in the mid- nineteenth century in England, St Helena (an isolated island), and Louisiana (United States) were vividly recorded and studied by the physicians. These reported outbreaks of paralysis were largely limited but were considered threatening enough by the observing physicians for broader attention. Despite this, other outbreaks went largely unreported for many years.[59]

It was only after the mid- nineteenth century in 1868 that the outbreaks of poliomyelitis were taken seriously. The trend of increasing frequency of outbreaks of poliomyelitis remained primarily limited to northern European countries for 25 years, where its epidemiological characteristics were thoroughly defined. The epidemic trends of the disease, which started in 1868, were first reported in Norway and later in other parts of Europe, North America and other

[58] Paul, J, R. (1971). *A history of Poliomyelitis, Yale studies in the history and medicine.* New Haven and London: Yale University Press.

[59] Paul, J, R. (1971). *A history of Poliomyelitis, Yale studies in the history and medicine.* New Haven and London: Yale University Press.

regions.[60] Since 1900 an irreversible pattern of epidemics of poliomyelitis started in much of the temperate regions and developed countries. One of the remarking patterns of the poliomyelitis epidemic was the increase in age of incidence in children. The infant paralysis caused by the diseases was observed in children of higher age group of 10 to 15 and above and even in adults.[61]

Poliomyelitis is a disease that became epidemiologically apparent only when it transformed into an epidemic nature. It is primarily considered to be a disease of the twentieth century. However, there are sufficient historical pieces of evidences on the occurrence of sporadic poliomyelitis causing paralysis in infants.

It was the epidemic and not an endemic form of the disease which recognized poliomyelitis as a public health problem. Epidemics of poliomyelitis attracted much-needed attention to the disease and generated funding for its treatment and research studies which was negligible in the endemic period.

From the epidemiological understanding, the epidemic nature of a disease is of considerable public health importance. This is primarily because, during an epidemic, the nature of disease transforms from being considered a minor illness to occurring as a significant illness or minor illness is followed by major illness occurring in greater frequency. In polio, this disease's transformation into a significant illness produced apparent long-term symptoms

[60] Sweden, 1880, parts of western Europe, 1880's or 1890's, the northeastern section of the USA, 1890's; the south eastern section of the USA about 1910 and elsewhere(Paul, J, R. (1971). *A history of Poliomyelitis, Yale studies in the history and medicine.* New Haven and London: Yale University Press; Paul, J, R.(1955). *Epidemiology of poliomyelitis.* In: *Poliomyelitis.* Geneva: World Health Organization: Monograph Series, 26)

[61]Paul, J, R. (1971). *A history of Poliomyelitis, Yale studies in the history and medicine.* New Haven and London: Yale University Press; Paul, J, R.(1955). *Epidemiology of poliomyelitis. In: Poliomyelitis.* Geneva: World Health Organization: Monograph Series, 26. (Retrieved from www.who.int);Freyclie, M.J. & Nielsen, J. (1955). *Incidence of poliomyelitis since 1920. In: Poliomyelitis*. Geneva: World Health Organization: Monograph Series, 26. (Retrieved from www.who.int)

of paralysis in a few children. It is estimated that only 3 – 4 per cent of all polio infection causes paralysis. In most children, this paralysis is short-lived, whereas it becomes a permanent lifelong disability in a few. During an epidemic year, when the number of polio infection cases increases, the prospects of children ending up with lifelong deformities increases tremendously.[62]

2.5 Fear of Poliomyelitis

In the case of polio, the actual polio disease recognized and emphasized during the epidemics was paralytic poliomyelitis, causing disability in children.[63] More than the polio infection, it was paralytic poliomyelitis during the epidemic, making the public anxious and fearful. The sight of a healthy child suddenly becoming paralytic with permanent deformities, mainly in the legs, was frightening for the general public.[64]

Poliomyelitis, among the other disease of the twentieth century, was different as it transformed into long-term symptoms of paralysis in a few children. Although there were other diseases with high mortality in this era, polio was considered more dreadful, causing paralysis. The frequent epidemics of poliomyelitis started a period of fear among the general public. It disturbed the public's everyday living and working during the outbreak period. All the public places were shut down. It greatly affected people's public and social life and infected both

[62] Paul, J, R. (1971). *A history of Poliomyelitis, Yale studies in the history and medicine.* New Haven and London: Yale University Press; Paul, J, R.(1955). *Epidemiology of poliomyelitis. In: Poliomyelitis.* Geneva: World Health Organization: Monograph Series, 26. (Retrieved from www.who.int)

[63] In United states only between the epidemic years in 1930s and 1940s the annual incidence of poliomyelitis's reached a high level causing more than 10,000 paralytic cases. (Paul, J, R. (1971). *A history of Poliomyelitis, Yale studies in the history and medicine.* New Haven and London: Yale University Press)

[64] Oshinsky, D.M. (2005). *Polio: An American Story*. New York: Oxford University Press; Paul, J, R. (1971). *A history of Poliomyelitis, Yale studies in the history and medicine.* New Haven and London: Yale University Press; Wilson, D.J. (2005). *Living with Polio: The Epidemic and its Survivors*. University of Chicago Press; Roger, N. (1958). *Dirt and Diseases: Polio before FDR*. Rutgers University Press.

adults and children equally. The constant fear of contracting polio infection during the epidemic bound the entire families within their homes.[65]

The uncertainty surrounding the disease causes and cure added to the fear of the public. Poliomyelitis terrified both the affected and non-effected families because of the unknown causes of poliomyelitis and the lack of any promising cure. The epidemics of the disease were cataclysmic, causing fear in the minds of the general public. The sudden occurrence of paralysis after fever in a previously healthy child was enough for the parents and the general public to fear the disease and the possibility of getting infected. The lifelong deformities created in a healthy child by this disease created an appalling image imprinted on the minds of the people who witnessed the polio epidemic era. This fear of disease among the public was enough to foster tremendous social pressure on the governments of western countries dashed with frequent polio epidemics to initiate policy action to treat and prevent polio. However, conquering polio disease was full of uncertainty. Because the world still does not have all the answers about the nature of the virus, how it is spread and its treatment or cure.[66]

2.6 Epidemics Changed the Scientific Approach to Poliomyelitis

The frequent epidemic and elevated fear of contracting poliomyelitis infection among the public was a significant push for scientific progress in the field of poliomyelitis before the 1950s. Many important scientific discoveries were made in understanding the epidemiology of the disease and its accurate diagnosis and treatment before the 1950s.

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[65] Oshinsky, D.M. (2005). *Polio: An American Story*. New York: Oxford University Press; Paul, J, R. (1971). *A history of Poliomyelitis, Yale studies in the history and medicine.* New Haven and London: Yale University Press; Wilson, D.J. (2005). *Living with Polio: The Epidemic and its Survivors*. University of Chicago Press; Roger, N. (1958). *Dirt and Diseases: Polio before FDR*. Rutgers University Press.

[66] Oshinsky, D.M. (2005). *Polio: An American Story*. New York: Oxford University Press; Paul, J, R. (1971). *A history of Poliomyelitis, Yale studies in the history and medicine.* New Haven and London: Yale University Press; Wilson, D.J. (2005). *Living with Polio: The Epidemic and its Survivors*. University of Chicago Press; Roger, N. (1958). *Dirt and Diseases: Polio before FDR*. Rutgers University Press.

In Europe and the United States, where much of the polio research was undertaken, the fear among people was intense. Defining the epidemiology of the disease and its causative agent started. Much of the initial research was taken to understand the epidemiology of the disease, its virus types and how it spread. Until the vaccination to prevent the diseases was not in foresight, the public health measures to control the diseases were primarily focused on preventing the disease. For treatment and rehabilitation of afflicted patients use of iron cages and therapies was prominent.[67]

The techniques to identify viruses were not developed until the twentieth century. Robert Koch's discoveries resulted in a significant shift in scientific focus to identifying microorganisms. His discoveries led to the beginning of the germ theory of disease and the birth of bacteriology as a discipline. At the beginning of the germ era, the scientific basis of public health rules for discovering viruses or diseases were explicitly laid down for its applications in laboratories.

Various viruses such as rabies, foot-and-mouth disease, smallpox and vaccinia were detected. Landsteiner, an immunologist and his assistant Popper in 1908 in Vienna successfully discovered the acute poliomyelitis virus.

The knowledge of the etiological agent of the poliomyelitis virus established that poliomyelitis was an infectious disease with an epidemic nature. Landsteiner's success was considered early and led to numerous scientific possibilities that were considered impossible

[67] Oshinsky, D.M. (2005). *Polio: An American Story*. New York: Oxford University Press; Paul, J, R. (1971). *A history of Poliomyelitis, Yale studies in the history and medicine.* New Haven and London: Yale University Press; Wilson, D.J. (2005). *Living with Polio: The Epidemic and its Survivors*. University of Chicago Press; Roger, N. (1958). *Dirt and Diseases: Polio before FDR*. Rutgers University Press; Payne, A.M.M. (1955). *Public-health measures in the control of poliomyelitis. In: Poliomyelitis*. Geneva: World Health Organization: Monograph Series, 26.

before this discovery. In the period from (1909- to 1914), hopes were high, and there was a general unrealistic belief among the scientific community that quick laboratory solutions were possible for all disease problems, particularly poliomyelitis.[68]

The successful isolating of poliovirus by Landsteiner opened the gates for laboratory work on experimental polio in 1910. There was a rush in interest among the scientists for extensive experimental work on infectious polio in laboratories. Between the 1912 and 1930 particularly in United States there was a notion that experimental poliomyelitis work is the only work need to be focused. Although research on experimental poliomyelitis infections progress was essential and needed at that time. But it also excluded other scientific endeavours on understanding the poliomyelitis disease.[69]

Simon Flexner, the director of Rockefeller Institute for Medical Research in New York, took advantage of the discovery of the polio agent by Landsteiner and started experimental work on polio. Rockefeller Institute was one of the highly equipped places with all the facilities to do the experimental work on polioviruses. Using experimental research, Simon and his colleagues showed the way for antibody formation in humans against polio infection in 1910. Flexner showed that monkeys' blood contains antibodies known at that time as 'germicidal substances', which made monkeys survive polio. Flexner experimental polio research used the experimental infection method to mix blood of monkeys with live poliovirus resulting in inactivating the poliovirus because of antibodies formation in the blood. Simultaneously other

[68] Paul, J, R. (1971). *A history of Poliomyelitis, Yale studies in the history and medicine.* New Haven and London: Yale University Press.
[69] Paul, J, R. (1971). *A history of Poliomyelitis, Yale studies in the history and medicine.* New Haven and London: Yale University Press.

researchers also shared similar results neutralizing humans and thus recovering from patients on antibodies formation in their bodies.[70]

In the era of experimental work on polio, the discovery by Flexner was one of the pioneering discoveries. Demonstration of the formation of antibodies in recovering polio patients laid the stage for significant scientific advances in polio vaccination development much later. After the discovery of poliovirus antibodies, hopes were high among researchers that polio could be conquered sooner. However, it seemed promising for vaccine-induced antibody production in humans to fight the poliovirus. It took many years for the required scientific breakthrough work to begin on polio vaccine development. Scientific progress by the year 1913 was constrained because of many factors. It was still difficult for scientists to find a cure or develop polio vaccination. Much scientific work on understanding the nature of the disease and technical tools for vaccine development was lacking. Many earlier scientists also stopped the polio research work on finding answers to polio disease immunization and cure. By 1914 World War I disrupted much of laboratories' research on polio worldwide, particularly in Europe.[71]

For a very long period, understanding dominated that the poliovirus enters the human central nervous system through the nose and olfactory cranial nerves. The nasal portal entry was firmly accepted in 1917. Later on, Simon Flexner and Lewis also concluded through their research work that poliovirus entered the human body through the nasal mucosa. During that period, a human's nasal portal entry of poliovirus was falsely accepted as a universal idea. This

[70]Oshinsky, D.M. (2005). *Polio: An American Story*. New York: Oxford University Press; Paul, J, R. (1971). *A history of Poliomyelitis, Yale studies in the history and medicine.* New Haven and London: Yale University Press.

[71]Oshinsky, D.M. (2005). *Polio: An American Story*. New York: Oxford University Press; Paul, J, R. (1971). *A history of Poliomyelitis, Yale studies in the history and medicine.* New Haven and London: Yale University Press.

false idea dominated the scientific understanding of polio disease for many years and was also considered a breakthrough in understanding the pathways of poliovirus pathogenies. Simultaneously preventive measures focused on spraying various chemicals into the nose to prevent poliovirus entry.[72]

By 1942 interest in understanding the pathways of poliovirus to the central nervous system was again developed. The need to re-examine how the poliovirus gained access to the human central nervous system developed. Because there were many dobouts among the scientific community on nasal mucosa entry of poliovirus despite its universal acceptance.[73]

It was only in 1951 when Professor Dorothy Millicent Horstmann of Yale Poliomyelitis Study Unit at Yale University scientifically established that it was the bloodstream where the poliovirus incubates, and the virus reaches the central nervous system. This settles much confusion on the pathways of poliovirus within the human body and how polio infection developed. It also started a series of field trials on inoculating human antibody blood serum to prevent paralytic attacks. This preventive method blocks disease progression at the minor stage, protecting against the attack on the central nervous system. Later this method of injecting antibodies was stopped.[74] However, the scientific breakthrough by DM Horstmann paved the

[72] Oshinsky, D.M. (2005). *Polio: An American Story*. New York: Oxford University Press; Paul, J, R. (1971). *A history of Poliomyelitis, Yale studies in the history and medicine.* New Haven and London: Yale University Press.

[73]Paul, J, R. (1971). *A history of Poliomyelitis, Yale studies in the history and medicine.* New Haven and London: Yale University Press.

[74] Using inoculation of convalescent blood for prevention of paralytic polio started in epidemic of 1928 in Sweden after this field trails were conducted in 1932. In 1951 using blood fraction (rich in antibodies), gamma globulin inoculation was used to prevent paralytic polio. The field trial of gamma globulin done by NFPI reduced the incidence of poliomyelitis. Despite the increase in antibody in humans in 1953 it was found that that mass scale use of gamma globulin was only effective when epidemics are predicted. This passive protection method was used for few years and later on abandon completely due to expensive nature and difficulty to carry it out on emergency basis. (Paul, J, R. (1971). *A history of Poliomyelitis, Yale studies in the history and medicine.* New Haven and London: Yale University Press)

way for polio vaccination development as one of the ultimate preventive methods to conquer poliomyelitis.

The world has to wait for years to progress in understanding and controlling the disease. One of the greatest mysteries and controversies for years surrounding poliomyelitis was its spread mode. A general idea was established at the beginning of the twentieth century that insects are responsible for the spread of poliomyelitis. There were many myths about how the virus spread, including the mode of spread from mosquitoes flying to filthy environments. These myths about insects spreading poliomyelitis were established in the era when for many other diseases, insects were considered the primary entity for spreading the diseases. Thus, insects played a cosmopolitan role in spreading the diseases.[75]

The occurrence of polio epidemics in summer temperate climates, similar to Yellow Fever (a summer disease), established the idea that polio similarly was carried by mosquitos and spread through biting humans. In 1912 flies were also seen as a possible vector of polio. Soon the fly's role in the epidemiology of spreading polio was considered universally. Similarly, public health measures were all focused on controlling the polio epidemics with the use of newly discovered insecticides reducing the population of flies to significant levels. Later on, with scientific advancement, it was understood that polio is spread by human-to-human contact with an infected person and the commonest portal through which the poliovirus enters

[75] Roger, N. (1958). *Dirt and Diseases: Polio before FDR*. Rutgers University Press; Payne, A.M.M. (1955). *Public-health measures in the control of poliomyelitis. In: Poliomyelitis*. Geneva: World Health Organization: Monograph Series, 26.

the human body is the mouth.[76] However, the myth of flies' role in the spread of polio lived for very long, even when it was known that flies do not spread poliomyelitis.[77]

Since the early twentieth century, the progress in tissue culture techniques has opened doors for culturing viruses in the laboratory. Subsequently, various attempts have been made since 1913 to culture poliovirus outside of the body in an artificial environment. However, it was only in 1948 when John Enders and his associates made successful attempts to cultivate poliovirus and produced scientific pieces of evidence from 1948 to 50 on growing three poliovirus serotypes. It was a milestone discovery in the history of poliovirus research which revolutionized the scientific field.[78]

Scientific understanding of the disease calmed much of the fear and uncertainty around poliomyelitis. Understanding the polio virus mode of entry into the body by mouth and its presence in the intestinal tract helped in removing uncertainty and fear of paralysis around the disease. This understanding of the polio disease established that poliovirus stays long in the intestine and does little harm. In many cases, it stays in the body and shows no symptoms at all or occasionally develops minor symptoms of fever. The poliovirus occasionally spreads to the spinal column, where it can develop paralysis and sometimes death.[79]

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[76] Roger, N. (1958). *Dirt and Diseases: Polio before FDR*. Rutgers University Press; Paul, J, R. (1971). *A history of Poliomyelitis, Yale studies in the history and medicine.* New Haven and London: Yale University Press.

[77] Roger, N. (1958). *Dirt and Diseases: Polio before FDR*. Rutgers University Press; Payne, A.M.M. (1955). *Public-health measures in the control of poliomyelitis. In: Poliomyelitis*. Geneva: World Health Organization: Monograph Series, 26.

[78]Paul, J, R. (1971). *A history of Poliomyelitis, Yale studies in the history and medicine.* New Haven and London: Yale University Press; Enders, J.F. (1955). *The present status of tissue-culture techniques in the study of the poliomyelitis viruses.* In*:* Poliomyelitis. Geneva: World Health Organization: Monograph Series, 26. (Retrieved from www.who.int)

[79] Paul, J, R. (1971). *A history of Poliomyelitis, Yale studies in the history and medicine.* New Haven and London: Yale University Press; Roger, N. (1958). *Dirt and Diseases: Polio before FDR*. Rutgers University Press.

It is estimated that out of two thousand people infected by poliovirus, about ten will develop paralytic polio. Of those ten, one will die, two or three will recover, and six or seven will remain paralyzed.[80]

2.7 Polio cure, *A distant dream*

After the discovery of poliovirus, modes of its transmission, pathways of its entry in humans and technical methods to the culture poliovirus, it is easier to consider the possibility of finding a cure for the paralytic polio disease was not far away. However, scientific research progress on finding some preventive methods such as vaccines was not the quickest path as thought so during that period. There were many obstacles to polio vaccine development.

Between 1900 and the 1930s, polio epidemics increased worldwide. This increased the number of polio treatment and rehabilitation patients. After World War I, polio as a disease became a policy priority by epidemic-affected countries. Polio patient care cost was expensive. Many patients needed support to afford the treatment and rehabilitation cost of polio. Several countries recognized that polio disease required a large sum of financial resources as there was an acute shortage of funds for the disease to support many polio patients. Similarly, polio research in laboratories was also expensive and in acute need of financial support for its scientific progress in treating and preventing the disease.[81]

Several countries recognizing the significant funding gaps for polio patient care and research shifted their focus towards advocating for private donations. However, patient care

[80] Paul, J, R. (1971). *A history of Poliomyelitis, Yale studies in the history and medicine.* New Haven and London: Yale University Press.

[81] Oshinsky, D.M. (2005). *Polio: An American Story*. New York: Oxford University Press; Paul, J, R. (1971). *A history of Poliomyelitis, Yale studies in the history and medicine.* New Haven and London: Yale University Press; Wilson, D.J. (2005). *Living with Polio: The Epidemic and its Survivors*. University of Chicago Press; Roger, N. (1958). *Dirt and Diseases: Polio before FDR*. Rutgers University Press.

was prioritized over research funding as treatment and rehabilitation costs were very expensive for polio patients. Several countries subsidized patient care for long-term treatment and rehabilitation from the crippling disease.[82]

2.8 Polio Rehabilitation in Warm Springs and Fund-Raising Campaign

The United States (US) President Franklin D. Roosevelt was one of the famous personalities known to be affected by the polio disability in 1921 prior to being elected as president. He founded the Warm Springs Institute for Rehabilitation in Warm Springs in Western Georgia in 1927s. The institute's primary focus was to provide a place for direct support for the rehabilitation of polio patients under a professional staff with the use of warm water present in Western Georgia. It also focuses on disseminating its observations and methods for treatment and rehabilitation of polio patients to medical institutions worldwide for its use. This was the most initial public support for paralysis-affected polio patients to get treatment and rehabilitation care. Sooner it became the only place in the country for providing physical therapy and rehabilitation to polio-afflicted patients.[83]

In the United States (US), the incidence of polio epidemics was high during the 1920s and 1930s. These epidemics left several people crippled with paralytic poliomyelitis. There was a countrywide opinion and appeal among the public and the medical community that

[82] Oshinsky, D.M. (2005). *Polio: An American Story*. New York: Oxford University Press; Paul, J, R. (1971). *A history of Poliomyelitis, Yale studies in the history and medicine.* New Haven and London: Yale University Press; Wilson, D.J. (2005). *Living with Polio: The Epidemic and its Survivors*. University of Chicago Press; Roger, N. (1958). *Dirt and Diseases: Polio before FDR*. Rutgers University Press.

[83] Oshinsky, D.M. (2005). *Polio: An American Story*. New York: Oxford University Press; Paul, J, R. (1971). *A history of Poliomyelitis, Yale studies in the history and medicine.* New Haven and London: Yale University Press; Wilson, D.J. (2005). *Living with Polio: The Epidemic and its Survivors*. University of Chicago Press; Roger, N. (1958). *Dirt and Diseases: Polio before FDR*. Rutgers University Press; Cutlip, S. M. (1965). *F.D.R.*, Polio, and March of Dimes. In: *Fund Raising in the Unites States Its Role in America's Philanthropy* (Chapter 9). New Brunswick & New Jersey: Rutgers University Press.

something needs to be done for polio-afflicted patient care and polio research. The horrifying polio epidemic was a national concern and priority in US democracy. Images of a paralyzed child with steel braces attached to his legs making courage to walk were used on polio fundraising posters. The devastating state of patients affected with polio paralysis influenced the public with feelings of compassion and an urge to contribute to this national cause. There was a surge in the amounts of funds contributed to polio. Thus, polio became a disease of national interest. Everyone was concerned about this dreadful disease, from the general public to the government and wanted some productive actions to tackle it.[84]

In March 1933, Franklin D. Roosevelt took charge as president of the US. During his presidential period, President Roosevelt put polio at the centre of the national agenda. As a national figure, Roosevelt was afflicted with polio, and his presidency years boosted the polio funding significantly.

Nationwide celebration of the president's birthday from 1934 until his death was used to raise funds to fight against polio. Presidents' Birthday ball was held annually on January 30th across the nation to raise funds. Presidents Birthday ball commission was formed in 1934 to use funds collected. The success of birthday balls preceded the foundation of the National Foundation for Infantile Paralysis (NFIP) in 1938 to fight polio. Roosevelt later renamed the foundation as 'March of Dimes'. The foundation was a non-profit organization for raising support and funds for polio.[85] The name March of Dimes was coined by entertainer Eddie

[84]Oshinsky, D.M. (2005). *Polio: An American Story*. New York: Oxford University Press; Paul, J, R. (1971). *A history of Poliomyelitis, Yale studies in the history and medicine.* New Haven and London: Yale University Press; Roger, N. (1958). *Dirt and Diseases: Polio before FDR*. Rutgers University Press; Cutlip, S. M. (1965). *F.D.R.,* Polio, and March of Dimes. In: *Fund Raising in the Unites States Its Role in America's Philanthropy* (Chapter 9). New Brunswick & New Jersey: Rutgers University Press.

[85] Oshinsky, D.M. (2005). *Polio: An American Story*. New York: Oxford University Press; Paul, J, R. (1971). *A history of Poliomyelitis, Yale studies in the history and medicine.* New Haven and London: Yale University Press; Roger, N. (1958). *Dirt and Diseases: Polio before FDR*. Rutgers University Press; Cutlip, S. M. (1965). *F.D.R.,* Polio, and March of Dimes. In: *Fund Raising in the Unites States Its Role in America's Philanthropy*

Cantor. The meaning of March of Dimes was that a small amount of money, *even a dime* can add to huge funds raised for the treatment and prevention of polio. In March of Dimes, fundraising campaign funds were conducted by volunteers to collect a small amount of money from people across the country.[86]

The succeeding presidents after Roosevelt also put polio on the major national agenda. President Harry Truman declared polio a threatening disease to US society in 1946 and called for a nationwide united effort to conquer it.[87]

The President's Birthday ball commission was closed up in 1938 and was replaced with NFIP. Mr. Basil O' Conner a close friend of Franklin D. Roosevelt became the president of the NFIP. As a private foundation, all efforts of NFIP were focused on a single disease, Poliomyelitis. This was something which was not seen before in the history of polio. It was supported by private philanthropies and was dependent on charitable donations from the public mostly from March of Dimes. Raising funds for the foundation was not difficult through the March of Dimes campaigns.[88]

(Chapter 9). New Brunswick & New Jersey: Rutgers University Press; Rose, D.W. (2016). *Friends and Partners: The Legacy of Franklin D. Roosevelt and Basil O'Connor in the History of Polio*. Academic Press.

[86]Oshinsky, D.M. (2005). *Polio: An American Story*. New York: Oxford University Press; Paul, J, R. (1971). *A history of Poliomyelitis, Yale studies in the history and medicine.* New Haven and London: Yale University Press; Roger, N. (1958). *Dirt and Diseases: Polio before FDR*. Rutgers University Press; Cutlip, S. M. (1965). *F.D.R.,* Polio, and March of Dimes. In: *Fund Raising in the Unites States Its Role in America's Philanthropy* (Chapter 9). New Brunswick & New Jersey: Rutgers University Press; Rose, D.W. (2016). *Friends and Partners: The Legacy of Franklin D. Roosevelt and Basil O'Connor in the History of Polio*. Academic Press.

[87] Oshinsky, D.M. (2005). *Polio: An American Story*. New York: Oxford University Press; Paul, J, R. (1971). *A history of Poliomyelitis, Yale studies in the history and medicine.* New Haven and London: Yale University Press; Cutlip, S. M. (1965). *F.D.R.,* Polio, and March of Dimes. In: *Fund Raising in the Unites States Its Role in America's Philanthropy* (Chapter 9). New Brunswick & New Jersey: Rutgers University Press.

[88] Oshinsky, D.M. (2005). *Polio: An American Story*. New York: Oxford University Press; Paul, J, R. (1971). *A history of Poliomyelitis, Yale studies in the history and medicine.* New Haven and London: Yale University Press; Roger, N. (1958). *Dirt and Diseases: Polio before FDR*. Rutgers University Press; Cutlip, S. M. (1965). *F.D.R.,* Polio, and March of Dimes. In: *Fund Raising in the Unites States Its Role in America's Philanthropy*

In the beginning, the absolute focus of the foundation was on fundraising to raise sufficient funds for the foundation's functioning. Within a short period of time nationwide expansion of its branches grew vastly across all the states of the US. The foundation played a major role by providing support for treatment and rehabilitation costs for polio-affected patients and later funded research on polio cure. Initially, the objective and focus of the foundation were to fund the patient care and hospitalization of those afflicted with polio and its paralysis. Also initiated activities of public education campaigns informing the public about the nature of the polio disease and ways to deal with it. The NFPI soon took a very prominent leadership role in providing treatment and rehabilitation of polio patient care supporting a large number of patients lacking funds for availing of expensive polio medical care services.[89]

2.9 The Unites States of America Leadership Role in Polio Research

After the World War, I similar to polio treatment and rehabilitation polio research in laboratories was also very expensive. It required expensive lab facilities, technical assistance and imported monkeys for conducting experiments.

A large number of universities and private research institutions were unable to fund the expensive polio research. Between the period of the 1920s and 1930s restricted funding was available for research activities from granting agencies. It was almost rare to grant funds for any single disease. Similarly, funding from private sources was also small and not sufficient.

(Chapter 9). New Brunswick & New Jersey: Rutgers University Press; Rose, D.W. (2016). *Friends and Partners: The Legacy of Franklin D. Roosevelt and Basil O'Connor in the History of Polio*. Academic Press.

[89] Oshinsky, D.M. (2005). *Polio: An American Story*. New York: Oxford University Press; Paul, J, R. (1971). *A history of Poliomyelitis, Yale studies in the history and medicine.* New Haven and London: Yale University Press; Roger, N. (1958). *Dirt and Diseases: Polio before FDR*. Rutgers University Press; Cutlip, S. M. (1965). *F.D.R.,* Polio, and March of Dimes. In: *Fund Raising in the Unites States Its Role in America's Philanthropy* (Chapter 9). New Brunswick & New Jersey: Rutgers University Press; Rose, D.W. (2016). *Friends and Partners: The Legacy of Franklin D. Roosevelt and Basil O'Connor in the History of Polio*. Academic Press.

Even institutions such as the Rockefeller Foundation were able to provide limited funds and were not adequate for polio-like expensive research work. Because of the shortage of funds and the expensive nature of polio research, many of the scientists working on polio had to stop their research work and move on to another scientific endeavour. Thus, the acute shortage of funds for polio research to investigate the nature of the disease, its treatment and for vaccine development delayed the overall scientific progress for a longer period.[90]

After World War II the momentum to support and strengthen the polio research work build up. There was already a universal concern among the public and government on the devastating nature of the disease. Compared to polio patient care progress in scientific research work on polio no longer could be ignored. But European countries after World War II were not in the capacity to provide the necessary financial support for polio research work.[91]

Much of later polio research work on vaccine development took place in the US. The country took a prominent leadership role in the world on polio vaccine development. In the US polio as a disease already was a national concern and among the top priorities for the government. Through March of Dimes, a large sum of money was flowing for polio patient treatment and care. Private foundations such as NFPI were established playing a worldwide prominent leadership role as a single largest organization focused exclusively on polio care and rehabilitation.[92]

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[90] Oshinsky, D.M. (2005). *Polio: An American Story*. New York: Oxford University Press; Paul, J, R. (1971). *A history of Poliomyelitis, Yale studies in the history and medicine.* New Haven and London: Yale University Press; Rose, D.W. (2016). *Friends and Partners: The Legacy of Franklin D. Roosevelt and Basil O'Connor in the History of Polio*. Academic Press.

[91] Oshinsky, D.M. (2005). *Polio: An American Story*. New York: Oxford University Press; Paul, J, R. (1971). *A history of Poliomyelitis, Yale studies in the history and medicine.* New Haven and London: Yale University Press; Rose, D.W. (2016). *Friends and Partners: The Legacy of Franklin D. Roosevelt and Basil O'Connor in the History of Polio*. Academic Press.

[92] Oshinsky, D.M. (2005). *Polio: An American Story*. New York: Oxford University Press; Paul, J, R. (1971). *A history of Poliomyelitis, Yale studies in the history and medicine.* New Haven and London: Yale University

The NFPI later shifted its focus to working on various individual aspects of the polio disease. This shift in organization goals was derived from strong determination and aptitude to dominate the global fight against paralytic polio. With this aim to lead the fight against polio paralysis foundation expanded its objectives focusing more on polio scientific research work and methods for its prevention.[93]

By the end of World War II, it was recognized among scientists that the multiplicity of poliovirus strains is an obstacle to scientific progress in polio research. It was already known by this time that poliovirus produced immunity in the human body. But how far success in developing this immunity is possible was questionable within the context of so many poliovirus strains present across the globe. There was a high demand among investigators that the problem of multiple strains of poliovirus needed to address with some permanent solution. Especially for the progress in the field of developing active immunization against the disease. Considering general agreement among the scientific community to address the problem of multiple strains of polio NFIP undertook a prominent role in addressing the issue. By the end of 1946, NFIP called a conference on the mechanism of immunity to polio where the problem of multiple strains of poliovirus was put forward for discussion.[94]

It was generally agreed upon in the conference that work on polio vaccine development could not progress until the different strains of polioviruses are known and classified. Although

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Press; Rose, D.W. (2016). *Friends and Partners: The Legacy of Franklin D. Roosevelt and Basil O'Connor in the History of Polio*. Academic Press.

[93] Oshinsky, D.M. (2005). *Polio: An American Story*. New York: Oxford University Press; Paul, J, R. (1971). *A history of Poliomyelitis, Yale studies in the history and medicine.* New Haven and London: Yale University Press; Rose, D.W. (2016). *Friends and Partners: The Legacy of Franklin D. Roosevelt and Basil O'Connor in the History of Polio*. Academic Press.

[94]Oshinsky, D.M. (2005). *Polio: An American Story*. New York: Oxford University Press; Paul, J, R. (1971). *A history of Poliomyelitis, Yale studies in the history and medicine.* New Haven and London: Yale University Press; Rose, D.W. (2016). *Friends and Partners: The Legacy of Franklin D. Roosevelt and Basil O'Connor in the History of Polio*. Academic Press.

the task was daunting the NFIP particularly was in a peculiar position to call for and fund such a project. By 1948 the project on typing polio strains from across the globe was started by NFIP called typing program. It was a unique and one of the major research endeavours in the field of polio considering the magnitude of work and funds required for the project. The project was important for the NFIP to establish itself as a global leader in the field of the fight against polio disease. By the year 1951, the committee of typing within a short period of three years of its existence collected from across the globe about 250 strains of poliovirus. Between the period of 1948 and 1955, the international typing project was completed by the committee.[95]

It became clear that the polio-like illness was very common in both animals and man. The family of polioviruses was very large including a large number of intestinal tract enteroviruses This large family of enteroviruses was included as a subgroup of newly formed picornaviruses. So, to classify human polioviruses an international committee was formed to define polioviruses and classify the large family of polioviruses. For a brief time, it appeared that the idea of polio vaccine development was unrealistic considering so many strains of polioviruses had been collected in the typing project. But soon through scientific analysis, it was found out that the family of polioviruses was not large enough as it was assumed. The family of polioviruses was fairly very small consisting of only three serotype members. The type I poliovirus was more prevalent followed by type II and type III. In 1955 Poliomyelitis virus was renamed poliovirus for ease of uniformity across several similar nomenclature groups.[96]

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[95] Oshinsky, D.M. (2005). *Polio: An American Story*. New York: Oxford University Press; Paul, J, R. (1971). *A history of Poliomyelitis, Yale studies in the history and medicine.* New Haven and London: Yale University Press; Rose, D.W. (2016). *Friends and Partners: The Legacy of Franklin D. Roosevelt and Basil O'Connor in the History of Polio*. Academic Press.

[96] Oshinsky, D.M. (2005). *Polio: An American Story*. New York: Oxford University Press; Paul, J, R. (1971). *A history of Poliomyelitis, Yale studies in the history and medicine.* New Haven and London: Yale University Press; Rose, D.W. (2016). *Friends and Partners: The Legacy of Franklin D. Roosevelt and Basil O'Connor in the History of Polio*. Academic Press.

2.10 The Triumph of the Polio Vaccine

After World War II in the early 1950s, several investigators conducted lab-based experiments on developing immunity against the poliovirus with either weakened or inactivated poliovirus vaccine. The scientific progress and technical developments in understanding the nature of poliovirus and disease progression in humans since the early 1940s provided the optimal environment for scientists to work finally on polio vaccine experiments. The possibilities of developing active immunization to prevent polio were very high among the scientific communities. Simultaneously the media attention on the development of vaccines and thereby public pressure was increasing. The increasing public pressure and demand to quickly find a permanent cure for the deadly disease was stressful for the scientists. Despite hard work put in by several scientists, the scientific progress towards polio vaccine development was moving very slowly compared to the high public expectations. There were concerns among scientists that the unwanted media and public pressure could hinder the rigour and quality required in scientific explorations. It may result in acceptance of nascent and premature results only leaving little scope for further scientific explorations.[97]

The typing project on polio strains not only made the scientific work in the field of polio vaccine possible. But it also laid the seeds for the cooperative and collaborative endeavour for polio research and vaccine development. After successfully implementing the typing program the NFIP took a more prominent position in polio research funding and identifying methods for immunity against the poliovirus.[98]

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[97]Oshinsky, D.M. (2005). *Polio: An American Story*. New York: Oxford University Press; Paul, J, R. (1971). *A history of Poliomyelitis, Yale studies in the history and medicine.* New Haven and London: Yale University Press.

[98] Oshinsky, D.M. (2005). *Polio: An American Story*. New York: Oxford University Press; Paul, J, R. (1971). *A history of Poliomyelitis, Yale studies in the history and medicine.* New Haven and London: Yale University Press; Rose, D.W. (2016). *Friends and Partners: The Legacy of Franklin D. Roosevelt and Basil O'Connor in the History of Polio*. Academic Press.

The objective of NFPI was to conquer the polio battle. The foundation expanded its role from just a granting agency to a more active role in polio vaccine development as chief strategist on polio vaccine-related decisions. The foundation leadership role laid down a system of cooperative collaboration of laboratories for the development and promotion of the polio vaccine.[99]

It started a policy initiative to direct and fund directly interuniversity laboratories' research work on polio. The NFIP provided long-term financial support to major US laboratories for polio research work. It was a first-of-its-kind cooperative venture to fund interuniversity research under the direct supervision of a committee for a single problem, polio. The polio research work in laboratories was directed by the supervision committee members. Thus, the lasting funding support for polio research work was realized through the pooling of financial resources.[100]

Among several scientists, polio research work got benefited under the new cooperative system in the US. By 1950 it was Dr Jonas Edward Salk of the University of Pittsburgh's research on inactivated polio vaccine (IPV) which caught the NFIP's attention. The NFIP supported and promoted the polio vaccine research work of Salk.[101]

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[99] Oshinsky, D.M. (2005). *Polio: An American Story*. New York: Oxford University Press; Paul, J, R. (1971). *A history of Poliomyelitis, Yale studies in the history and medicine.* New Haven and London: Yale University Press; Rose, D.W. (2016). *Friends and Partners: The Legacy of Franklin D. Roosevelt and Basil O'Connor in the History of Polio*. Academic Press.

[100] Oshinsky, D.M. (2005). *Polio: An American Story*. New York: Oxford University Press; Paul, J, R. (1971). *A history of Poliomyelitis, Yale studies in the history and medicine.* New Haven and London: Yale University Press; Rose, D.W. (2016). *Friends and Partners: The Legacy of Franklin D. Roosevelt and Basil O'Connor in the History of Polio*. Academic Press.

[101] Oshinsky, D.M. (2005). *Polio: An American Story*. New York: Oxford University Press; Paul, J, R. (1971). *A history of Poliomyelitis, Yale studies in the history and medicine.* New Haven and London: Yale University Press; Rose, D.W. (2016). *Friends and Partners: The Legacy of Franklin D. Roosevelt and Basil O'Connor in the History of Polio*. Academic Press.

Dr Salk was an American virologist and medical researcher at the University of Pittsburgh. Salk's research on the polio vaccine met with success in 1953 with the development of the first inactivated polio vaccine.

Salk made use of a series of scientific discoveries made before developing the first polio vaccine. The method to inactivate poliovirus with formaldehyde developed by Maurice Brodie and the cell culture technique developed by John Enders was advantageous for Salk to finally accomplish the goal of inactivated polio vaccine.[102]

Salk developed inactivated polio vaccine using the methods of inactivation of poliovirus. For this Salk developed a theory of inactivation of poliovirus. Later Salk extensively experimented in his laboratories on the efficacy and safety of his inactivated polio vaccine first on monkeys and later on in children. Salk through his scientific expertise proved that compared to natural infection killed virus vaccine gives protection against the polio virus and this method can be used for gaining induced protective polio antibodies in the human body.[103]

An immunization committee was formed by NFIP for assessing the safety, and efficacy and guiding the implementation of the polio vaccine. Later on, due to the inability of the immunization committee to perform, in 1953 a vaccine advisory committee, and an executive committee were formed for facilitating plans on the polio vaccine. Salk vaccine got full financial and administrative support for its development and later on for its field-level implementation from NFIP. After Salk's success in developing the first polio vaccine. The

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[102] Oshinsky, D.M. (2005). *Polio: An American Story*. New York: Oxford University Press; Paul, J, R. (1971). *A history of Poliomyelitis, Yale studies in the history and medicine.* New Haven and London: Yale University Press; Rose, D.W. (2016). *Friends and Partners: The Legacy of Franklin D. Roosevelt and Basil O'Connor in the History of Polio*. Academic Press; Offit, A. P. (2005). *The Cutter Incident: How America's First Polio Vaccine Led to the Growing Vaccine Crisis*. New Haven: Yale University Press.

[103]Oshinsky, D.M. (2005). *Polio: An American Story*. New York: Oxford University Press; Paul, J, R. (1971). *A history of Poliomyelitis, Yale studies in the history and medicine.* New Haven and London: Yale University Press.

vaccine advisory committee accepted Salk IPV and expedited its implementation and promoting plans. After the successful administration of IPV to children by Salk large field trial of Salk-type vaccine was initiated sooner by NFIP.[104]

After the discovery of the first polio vaccine. It did not take long for the field trial of Salk's vaccine to begin. The NFPI advisory committee called for a mass field trial on Salk's vaccine in December 1953 and laid the plans for its implementation. These field trials were large-scale and conducted in both urban and rural areas with the purpose to determine the safety and effectiveness of vaccines. Children from across the states, and different socioeconomic classes participated in the field trials.[105]

The national field trials lasted for two years and were evaluated thoroughly by Dr Thomas Francis Jr. director of the Poliomyelitis Vaccine Evaluation Centre at the University of Michigan School of Public Health. On April 12th 1955 a huge crowd consisting of 500 scientists, physicians, and reporters gathered at the University of Michigan's, Ann Arbor, Rackham Auditorium. The meeting was called to inform on the results of polio vaccine field trials. This meeting was jointly sponsored by the University of Michigan and the National Foundation for Infantile Paralysis. Dr Thomas Francis Jr. heading the meeting announced to the world that the first polio vaccine is *effective, potent and safe.* Dr Franscis's report on field trials of vaccine concluded that the Salk's polio vaccine prevents 80 to 90 per cent of paralytic

[104] Oshinsky, D.M. (2005). *Polio: An American Story*. New York: Oxford University Press; Paul, J, R. (1971). *A history of Poliomyelitis, Yale studies in the history and medicine.* New Haven and London: Yale University Press; Rose, D.W. (2016). *Friends and Partners: The Legacy of Franklin D. Roosevelt and Basil O'Connor in the History of Polio*. Academic Press; Offit, A. P. (2005). *The Cutter Incident: How America's First Polio Vaccine Led to the Growing Vaccine Crisis*. New Haven: Yale University Press.

[105]Oshinsky, D.M. (2005). *Polio: An American Story*. New York: Oxford University Press; Paul, J, R. (1971). *A history of Poliomyelitis, Yale studies in the history and medicine.* New Haven and London: Yale University Press.

polio. The antibody response of the vaccine came out good providing protection against the poliovirus. But a moderate decline in the level of antibodies after five months.[106]

The field trials of the vaccine were successful in inoculating 1,829,916 children without any serious side effects or mishaps among children with very few children suffering any reactions. Around 1013 children inoculated developed polio and only one child died. These findings based on vaccine field trials data settled much of the apprehensions on polio vaccine laboratory data. Particularly it negated speculative fears and reassured the safety of the vaccine for children.[107]

Both efficacy and potency of the first polio vaccine were successfully proven through field trials. The unprecedented large-scale Salk vaccine field trials, its evaluation and meeting to disseminate its findings to the world cost millions of dollars which were only made possible through grants of a total of $7,500,000 donated to NFIP through March of Dimes.[108]

Fearful and anxious parents sigh in relief with the media announcement of the success of the Salk polio vaccine field trials. Reinforcing the laboratory findings there was no more doubt about preventing inoculated children from the paralytic poliovirus. The media attention and demand for commercial manufacturing of polio vaccine increased after the success of

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[106] Oshinsky, D.M. (2005). *Polio: An American Story*. New York: Oxford University Press; Paul, J, R. (1971). *A history of Poliomyelitis, Yale studies in the history and medicine.* New Haven and London: Yale University Press; Rose, D.W. (2016). *Friends and Partners: The Legacy of Franklin D. Roosevelt and Basil O'Connor in the History of Polio*. Academic Press.

[107]Oshinsky, D.M. (2005). *Polio: An American Story*. New York: Oxford University Press; Paul, J, R. (1971). *A history of Poliomyelitis, Yale studies in the history and medicine.* New Haven and London: Yale University Press.

[108] Oshinsky, D.M. (2005). *Polio: An American Story*. New York: Oxford University Press; Paul, J, R. (1971). *A history of Poliomyelitis, Yale studies in the history and medicine.* New Haven and London: Yale University Press; Polio Vaccine Trial Announcement 1955 (nd.) *The University of Michigan, School of Public Health.* (Retrieved from https://sph.umich.edu/polio/)

field trials of Salk vaccine announcements. Thus, members of the licensing committee did not delay the process to give the green flag to mass production of the Salk vaccine.[109]

Five private manufacturers laboratories were given commercial licenses to manufacture and distribute doses of Salk's polio vaccine. The mass-scale production started, and a national vaccination program to inoculate children began in the US on April 14th 1955. However, just 15 days after the Ann Arbor meeting in Michigan, it was distressing for the public health officials and the public that many children vaccinated with the Salk vaccine were attacked by paralytic polio. The paralytic polio caused to children by the polio vaccine changed the course of polio vaccine policy in the US and later in the world.[110]

2.11 Cold War, USSR and Live Oral Polio Vaccine

In the twentieth century, polio vaccine research work commenced in the environment of biomedical discoveries. Salk vaccine research and development got immense support from NFIP. After the discovery of inactivated polio vaccine by Salk, the interest of NFIP was minor in supporting other scientific research on polio, particularly on promoting the live polio vaccine. Thus, Dr Albert Sabin's live polio vaccine lacked the necessary support to test the efficacy of its live polio vaccine and promote the vaccine within the US.[111]

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[109]Oshinsky, D.M. (2005). *Polio: An American Story*. New York: Oxford University Press; Paul, J, R. (1971). *A history of Poliomyelitis, Yale studies in the history and medicine.* New Haven and London: Yale University Press; Offit, A. P. (2005). *The Cutter Incident: How America's First Polio Vaccine Led to the Growing Vaccine Crisis*. New Haven: Yale University Press.

[110] Oshinsky, D.M. (2005). *Polio: An American Story*. New York: Oxford University Press; Paul, J, R. (1971). *A history of Poliomyelitis, Yale studies in the history and medicine.* New Haven and London: Yale University Press; Offit, A. P. (2005). *The Cutter Incident: How America's First Polio Vaccine Led to the Growing Vaccine Crisis*. New Haven: Yale University Press.

[111] Oshinsky, D.M. (2005). *Polio: An American Story*. New York: Oxford University Press; Paul, J, R. (1971). *A history of Poliomyelitis, Yale studies in the history and medicine.* New Haven and London: Yale University Press.

Much evidence on the Sabin's live oral polio vaccine came from large-scale field trials during the cold war period. The safety of the oral polio vaccine was assured from the mass application of the vaccine outside the US.

Unlike the Salk vaccine, live polio vaccine research and development involved various countries' experts. The research and development of the live polio vaccine was a collaborative network of polio researchers in different countries. It gave researchers from several countries to discuss the efficacy and limitations of the live polio vaccine. Consequently, it has a much wider spread compared to the Salk vaccine. It involved a broad range of experts and the participation of public health officials of different countries beyond the US.[112]

During the Cold War, the Salk vaccine got much support in the United States, whereas the Sabin live polio vaccine got support from Soviet Union countries. Many scientific field trials to assure the safety and efficacy of Sabin's polio vaccine took place in Soviet Union countries by scientists from the Institute of Poliomyelitis Research Academy of Medical Sciences in Moscow. This institute researched Sabin's donated live poliovirus strains and used the live polio vaccine for mass immunization of field trials in the USSR region.[113]

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[112] Paul, J, R. (1971). *A history of Poliomyelitis, Yale studies in the history and medicine.* New Haven and London: Yale University Press; Pan American Sanitary Bureau. (1959). *Live Poliovirus Vaccine: Papers Presented and Discussions Held at the First International Conference on Live Poliovirus Vaccines*. Pan American Sanitary Bureau, Regional office of the World Health Organization; Chumakov, M.P., Voroshilova, M.K., Vasilieva, K.A., et al. (1959). Preliminary report on mass oral immunization of population against poliomyelitis with live virus vaccine from A.B. Sabin's attenuated strains. In *First International Conference on Live Poliovirus Vaccines*. Washington, DC, Pan American Sanitary Bureau Scientific Publication. 44, 517-529; Pan American Sanitary Bureau. (1960). *Live Poliovirus Vaccine: Papers Presented and Discussions Held at the Second International Conference on Live Poliovirus Vaccines*. Pan American Sanitary Bureau, Regional office of the World Health Organization; World Health Organization. (1958). *Expert Committee on Poliomyelitis: Second Report*. World Health Organization Technical Report Series No.145, Switzerland. (Retrieved from www.who.int);World Health Organization. (1960). *Expert Committee on Poliomyelitis: Third Report*. World Health Organization Technical Report Series No. 203, Switzerland. (Retrieved from www.who.int)

[113] World Health Organization. (1958). *Expert Committee on Poliomyelitis: Second Report*. World Health Organization Technical Report Series No.145, Switzerland. (Retrieved from www.who.int); World Health Organization. (1960). *Expert Committee on Poliomyelitis: Third Report*. World Health Organization Technical Report Series No. 203, Switzerland. (Retrieved from www.who.int); Oshinsky, D.M. (2005). *Polio: An American Story*. New York: Oxford University Press; Paul, J, R. (1971). *A history of Poliomyelitis, Yale studies in the history and medicine.* New Haven and London: Yale University Press; Vargha, D. (2018). *Polio Across*

The use of the Salk vaccine in 1957 in the USSR region did not result in a substantial reduction in polio cases, and overall progress was too small. Thus, the results from using the Salk vaccine were considered possible, and mass-level use of the live polio vaccine was initiated. The live polio vaccine began in 1956 in USSR through large-scale mass vaccination campaigns using Sabin's donated live strains.[114] The mass immunization campaigns using the oral polio vaccine showed remarkable results, and its findings were shared at the first live polio vaccine conference in 1959 and the second in 1960.[115]

Strong support was given to using Sabin's live polio vaccine against the Salk's vaccine at the conferences and by the WHO Expert Committee on Poliomyelitis members. Sabin's polio vaccine was economically and operationally less problematic and more effective than Salk's polio vaccine. Ensuring the safety of Sabin's polio vaccine, scientists emphasized the speed of administering oral polio vaccine to the population at the mass level and the effectiveness of Sabin's oral polio vaccine to eradicate in polio epidemic countries. Thus, based

the Iron Curtain Hungary's Cold War With an Epidemic. Cambridge University Press; Pan American Sanitary Bureau. (1959). *Live Poliovirus Vaccine: Papers Presented and Discussions Held at the First International Conference on Live Poliovirus Vaccines*. Pan American Sanitary Bureau, Regional office of the World Health Organization; Chumakov, M.P., Voroshilova, M.K., Vasilieva, K.A., et al. (1959). Preliminary report on mass oral immunization of population against poliomyelitis with live virus vaccine from A.B. Sabin's attenuated strains. In *First International Conference on Live Poliovirus Vaccines*. Washington, DC, Pan American Sanitary Bureau Scientific Publication. 44, 517-529; Pan American Sanitary Bureau. (1960). *Live Poliovirus Vaccine: Papers Presented and Discussions Held at the Second International Conference on Live Poliovirus Vaccines*. Pan American Sanitary Bureau, Regional office of the World Health Organization.

[114] World Health Organization. (1958). *Expert Committee on Poliomyelitis: Second Report*. World Health Organization Technical Report Series No.145, Switzerland. (Retrieved from www.who.int); World Health Organization. (1960). *Expert Committee on Poliomyelitis: Third Report*. World Health Organization Technical Report Series No. 203, Switzerland. (Retrieved from www.who.int)

[115]Pan American Sanitary Bureau. (1959). *Live Poliovirus Vaccine: Papers Presented and Discussions Held at the First International Conference on Live Poliovirus Vaccines*. Pan American Sanitary Bureau, Regional office of the World Health Organization; Chumakov, M.P., Voroshilova, M.K., Vasilieva, K.A., et al. (1959). Preliminary report on mass oral immunization of population against poliomyelitis with live virus vaccine from A.B. Sabin's attenuated strains. In *First International Conference on Live Poliovirus Vaccines*. Washington, DC, Pan American Sanitary Bureau Scientific Publication. 44, 517-529; Pan American Sanitary Bureau. (1960). *Live Poliovirus Vaccine: Papers Presented and Discussions Held at the Second International Conference on Live Poliovirus Vaccines*. Pan American Sanitary Bureau, Regional office of the World Health Organization.

on experimental evidence from field trials in the USSR, Sabin's OPV providing long-term immunity was considered feasible for eradicating the polioviruses and was promoted to the global community to overcome many of the problems encountered in the use of Salk's polio vaccine.[116] Thus Sabin oral polio vaccine got widespread approval from other countries outside of the US, where massive polio immunization programs using the Sabin live polio vaccine successfully eliminated polio.

2.12 Salk or Sabin Polio Vaccine

The news on the development of Salk first inactivated polio vaccine was reliving to the countries and general suffering from frequent polio outbreaks. The optimism to conquer the fight against the paralytic polio disease became possible with the Salk polio vaccine. The epidemic became a vaccine-preventable disease with the discovery of the first polio vaccine. However, it was never imagined in the history of polio scientific research work that polio epidemic-prone countries would have to choose polio vaccines with the development of live oral polio vaccine. Both inactivated (killed) injectable polio vaccine (IPV) developed by Dr Jonas Salk and live attenuated (weakened) oral polio vaccine (OPV) developed by Dr Albert Sabin have their unique advantages and disadvantages for conquering the battle against the paralyzing poliovirus.

[116] Pan American Sanitary Bureau. (1959). *Live Poliovirus Vaccine: Papers Presented and Discussions Held at the First International Conference on Live Poliovirus Vaccines*. Pan American Sanitary Bureau, Regional office of the World Health Organization; Chumakov, M.P., Voroshilova, M.K., Vasilieva, K.A., et al. (1959). Preliminary report on mass oral immunization of population against poliomyelitis with live virus vaccine from A.B. Sabin's attenuated strains. In *First International Conference on Live Poliovirus Vaccines*. Washington, DC, Pan American Sanitary Bureau Scientific Publication. 44, 517-529; Pan American Sanitary Bureau. (1960). *Live Poliovirus Vaccine: Papers Presented and Discussions Held at the Second International Conference on Live Poliovirus Vaccines*. Pan American Sanitary Bureau, Regional office of the World Health Organization; World Health Organization. (1960). *Expert Committee on Poliomyelitis: Third Report*. World Health Organization Technical Report Series No. 203, Switzerland. (Retrieved from www.who.int)

Both vaccines were designed to produce immunity in vaccines recipient against the polio virus. Development of polio vaccines generated a sense of hope among the people against the paralyzing disease. However, there were several advantages of OPV over IPV, leading to its widespread use for polio eradication. There were many epidemiological and economic reasons for adopting and promoting Sabin's vaccines in the US and other developed countries.

There were several differences between the two vaccines. Salk vaccine was a dead vaccine composed of inactivated killed viruses. It prevents paralysis and produces immunity by preventing the poliovirus from not reaching the human nervous system. However, the vaccine did not provide a natural method of inducing immunity in the population and was ineffective in preventing the spread of outbreaks and infection. It also does not protect the close contact of vaccinated individuals from acquiring individual protection against polio infection. Thus, polio-infected individuals could spread through faecal matters poliovirus and infect other people.[117]

Sabin's OPV was the first live vaccine and was considered a breakthrough in the vaccinology discipline. Sabin OPV was made of weakened live viruses consisting of attenuated three polioviruses (type1, type2, type3). Compared to Salk's vaccine (80 per cent), it protected the children against the poliovirus 100 per cent. Sabin vaccine does not require repeated boosters as it provides prolonged immunity to mild infection. It acts quickly, and immunity against the virus is achieved in a few days. Because it is administered orally, it could be given

[117] Melnick. J.L. (1978). Advantages and disadvantages of killed and live poliomyelitis vaccines, *Bull World Health Organization*, 56(1): 21-38s; Blume, S. & Geesink, I. (2000). Essay on Science And Society: A Brief History of Polio Vaccines. *Science*, 288(5471), 1593 – 1594; Oshinsky, D.M. (2005). *Polio: An American Story*. New York: Oxford University Press; Paul, J, R. (1971). *A history of Poliomyelitis, Yale studies in the history and medicine.* New Haven and London: Yale University Press; World Health Organization. (1960). *Expert Committee on Poliomyelitis: Third Report*. World Health Organization Technical Report Series No. 203, Switzerland. (Retrieved from www.who.int); Offit, A. P. (2005). *The Cutter Incident: How America's First Polio Vaccine Led to the Growing Vaccine Crisis*. New Haven: Yale University Press.

by unskilled people. Hence it was cheap to manufacture. It was five times less expensive than Salk's vaccine. It was more acceptable and accessible to administer among children than needles, syringes and trained staff used in Salk's vaccine. It requires a single dose during an outbreak. The vaccine also has the prospects of passive vaccination, where the virus spreads from one person to another, immunizing people. The vaccine virus multiplies in the intestines of children many times excreted through faecal matter and sewage, protecting people in contact with children. Such children develop antibodies even though they are not vaccinated (called 'contact immunity"). The only risk associated with live vaccines was the virus's spread to humans, causing paralytic poliomyelitis.[118]

2.13 Seeds of Polio Eradication

After successful large-scale field trials in USSR and a few east European countries, the live polio vaccine gained massive popularity, especially its advantage in eliminating poliovirus.[119]

Initially, the US adopted Salk's inactivated vaccine and began its widespread use in 1955. Later in the mid-1960s, there was a shift in vaccine policy in the US and Sabin's live attenuated vaccines (OPVs) were used in the national polio vaccination program in the country. Within five years, this shift in vaccines in the US was driven by various factors.

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[118] Melnick. J.L. (1978). Advantages and disadvantages of killed and live poliomyelitis vaccines, *Bull World Health Organization*, 56(1): 21-38s; Blume, S. & Geesink, I. (2000). Essay on Science And Society: A Brief History of Polio Vaccines. *Science*, 288(5471), 1593 – 1594; Oshinsky, D.M. (2005). *Polio: An American Story*. New York: Oxford University Press; Paul, J, R. (1971). *A history of Poliomyelitis, Yale studies in the history and medicine.* New Haven and London: Yale University Press; World Health Organization. (1960). *Expert Committee on Poliomyelitis: Third Report*. World Health Organization Technical Report Series No. 203, Switzerland. (Retrieved from www.who.int); Offit, A. P. (2005). *The Cutter Incident: How America's First Polio Vaccine Led to the Growing Vaccine Crisis*. New Haven: Yale University Press.

[119] World Health Organization. (1960). *Expert Committee on Poliomyelitis: Third Report*. World Health Organization Technical Report Series No. 203, Switzerland. (Retrieved from www.who.int)

After the tragic 1955 Cutter incident, Salk's polio vaccine started losing its acceptance within the population. Cutter laboratories failed to inactivate the polio virus used in the vaccine resulting in live polio virus injected into children paralyzing and death some children. The Cutter incident occurred in the states of California, Idaho, Washington, Illinois and Colorado. A series of investigations found that children were paralyzed after getting the Cutter poliomyelitis vaccine and not through natural infections. For the safety of the children after the incident, the IPV use was temporarily stopped. It was the worst disaster in the history of the polio vaccine. However, safety protocols were set up by the government to check the vaccine's safety before its mass application to the population. However, such safety procedures were not followed properly. After the Cutter incidence, investigations showed that Cutter laboratories had difficulties in inactivating the poliovirus per the Salk guidelines and manufacturing protocols. However, laboratory officials informed about it neither the government nor Salk. After the Cutter incident, there was criticism of Cutter laboratories, John Salk and the National Foundation, which licensed the Cutter company from physicians, scientists, professional organizations, public health officials and politicians. The Cutter laboratories blamed the inadequate methods of Salk for the inactivation of the virus and the government for its standards and manufacturers. Even Salk's theory of inactivation was critiqued for being unscientific. The National Foundation was blamed for having rushed the clinical trials of the vaccine and forced the government to license a vaccine that was not safe and effective.[120]

Consequently, for IPV, there was apprehension about the safety of the vaccine and its acceptance among the public decreased. New standards for ensuring vaccine safety were

[120] Oshinsky, D.M. (2005). *Polio: An American Story*. New York: Oxford University Press; Paul, J, R. (1971). *A history of Poliomyelitis, Yale studies in the history and medicine.* New Haven and London: Yale University Press; Offit, A. P. (2005). *The Cutter Incident: How America's First Polio Vaccine Led to the Growing Vaccine Crisis*. New Haven: Yale University Press.

introduced, and IPV was distributed again in the later part of 1955 and continued in 1955 and 1961. There was no reported case of paralysis because of IPV. This proved satisfactorily that Salk's vaccine was safe. However, despite the claims of government and public health officials on vaccine safety, there was reluctance to take the vaccine public. Simultaneously the doctors, public health officials and polio experts were divided in their opinion to recommend the polio vaccine. The American Academy of paediatrics recommends discontinuing IPV. In this environment of uncertainty on the safety of the polio vaccine. There was a great dilemma among the parents of the children whether to take a polio vaccine which could cause paralysis, or not take the vaccine and get infected with polio. [121]

It was known that IPV is not 100 per cent effective after three doses of vaccine. By the 1960s, it was apparent that Salk's inactivated polio vaccine could not achieve the epidemiological goals of eradicating the disease. Salk's vaccine was not wholly effective in breaking the chains of transmission. Polio epidemics were still occurring in the United States, and children were getting infected through natural infections.[122]

Since 1955 when the Salk's polio vaccine was licensed in the US, the number of polio paralyzed cases reported decreased. Even after the Cutter incident, from 1955 to 1961, the incidence of paralysis declined to approximately 90 per cent (two per one hundred thousand).

[121] Oshinsky, D.M. (2005). *Polio: An American Story*. New York: Oxford University Press; Paul, J, R. (1971). *A history of Poliomyelitis, Yale studies in the history and medicine.* New Haven and London: Yale University Press; Offit, A. P. (2005). *The Cutter Incident: How America's First Polio Vaccine Led to the Growing Vaccine Crisis*. New Haven: Yale University Press.

[122] Oshinsky, D.M. (2005). *Polio: An American Story*. New York: Oxford University Press; Paul, J, R. (1971). *A history of Poliomyelitis, Yale studies in the history and medicine.* New Haven and London: Yale University Press; Offit, A. P. (2005). *The Cutter Incident: How America's First Polio Vaccine Led to the Growing Vaccine Crisis*. New Haven: Yale University Press.

Although there was evidence that the Salk vaccine was safe and effective as the incidence of polio was declining dramatically in the US.[123]

The Cutter incident and the goal of eradicating polio made scientists and public health officials change the polio vaccine in 1961 to Sabin. The many advantages of OPV vs IPV led to this shift in vaccines in the US.

Although significant risks were associated with the live poliovirus vaccine and safety issues, it was considered adequate to eradicate the disease. Many scientists and an advisory committee to the United States surgeon general in 1961 stated that over the benefits of OPV, there are severe risks of large-scale vaccine trials using live, weakened polio virus. It is evident through scientific studies that OPV could be more dangerous as weakened poliovirus has abilities to cause paralysis. However, such warnings were generally ignored by policy decision-makers. Despite knowing the risk of OPV, its benefits outweighed its risks, and it was licensed. The disadvantageous risk of OPV was considered a rare event with an estimated low risk by 1960. It was estimated that Sabin's vaccine causes paralysis in one of seven hundred fifty thousand immunized children only after the first dose, and it is a rare event.[124] The mass application of OPV in the USSR and some countries in East European and Asia ensured much of the concerns on the safety of the live polio vaccine among children for its large-scale use in

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[123] Oshinsky, D.M. (2005). *Polio: An American Story*. New York: Oxford University Press; Paul, J, R. (1971). *A history of Poliomyelitis, Yale studies in the history and medicine.* New Haven and London: Yale University Press; Offit, A. P. (2005). *The Cutter Incident: How America's First Polio Vaccine Led to the Growing Vaccine Crisis*. New Haven: Yale University Press; Krieger, J. (1955, Nov 20). Polio Vaccine Now Seen as a Complete Success: Only Remaining Question. *New York Times*, p.E8. (Retrieved from ProQuest Historical Newspapers Database, www. proquest.com)

124 Melnick. J.L. (1978). Advantages and disadvantages of killed and live poliomyelitis vaccines, *Bull World Health Organization*, 56(1): 21-38s; Blume, S. & Geesink, I. (2000). Essay on Science And Society: A Brief History of Polio Vaccines. *Science*, 288(5471), 1593 – 1594; Offit, A. P. (2005). *The Cutter Incident: How America's First Polio Vaccine Led to the Growing Vaccine Crisis*. New Haven: Yale University Press; Oshinsky, D.M. (2005). *Polio: An American Story*. New York: Oxford University Press; Paul, J, R. (1971). *A history of Poliomyelitis, Yale studies in the history and medicine.* New Haven and London: Yale University Press.

the US and other industrialized countries as well for its worldwide use in polio-endemic countries.[125]

After the success of the results of the oral polio vaccine in the Soviet Union, the USA shifted to OPV from IPV in 1961 and licensed it in the USA in 1963 and began widespread polio vaccination without a field trial. The OPV was quickly administered to millions of children in the United States in sugar cubes which contained the polio vaccine. Dr Sabin discovered the innovative way to administer the polio vaccine to children through a sugar cube. This quick and easy method was widely used in USSR and other developed countries.

However, other developed countries such as Netherland, Sweden, Iceland, Norway, Denmark, Finland, and Holland continued using Salk's killed polio vaccine. Salk's polio vaccine, introduced in the middle of the 1950s, successfully eliminated poliovirus by the 1960s. Contrary to the claims, Salk's IPV was able to protect long duration to the populations of these countries and was highly immunogenic. Only a few cases of sporadic imported cases were reported after eliminating poliovirus. In the Netherlands, polio epidemics were reported in 1978 and 1992 among unvaccinated susceptible populations [126]

From a health economics perspective, the US calculated the epidemiological and economic cost of choosing a vaccine and the cost to the health service system for administering

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[125] Paul, J, R. (1971). *A history of Poliomyelitis, Yale studies in the history and medicine.* New Haven and London: Yale University Press; Vargha, D. (2018). *Polio Across the Iron Curtain Hungary's Cold War With an Epidemic*. Cambridge University Press; World Health Organization. (1960). *Expert Committee on Poliomyelitis: Third Report*. World Health Organization Technical Report Series No. 203, Switzerland. (Retrieved from www.who.int)

[126] Bottiger, M. (1993). The elimination of polio in the Scandinavian countries. *Public Health Review*, 21(1-2), 27-33; Bijkerk, H. (1979). Surveillance and Control of Poliomyelitis in the Netherlands. *Canadian Medical Association Journal*, 120(8), 905-906; Hofman, B. (1972). Poliomyelitis in the Netherlands 1956-69: The influence of a vaccination programme with inactivated polio vaccine. *Bulletin of World Health Organization*, 46(6), 735-745; Rumke, H.C., Oostvogel, P.M., Steenis, G.V., & Loon, A.M.V. (1995). The Netherlands: a review of population immunity and exposure between the epidemics in 1978 and 1992. *Epidemiological & Infection*, 115(2), 289-298.

vaccination campaigns. The final decision for starting a vaccination campaign for polio was based on the cost of protection provided to the population and the social efficacy in avoiding the losses incurred on the individuals because of polio disease. Apart from epidemiological, social, and economic efficacy, political factors and vested interest of manufacturers of polio vaccines were also involved in promoting Sabin's OPV in developed and developing countries by the US.[127]

The initial public health goal of the US was only to vaccinate the children and control paralytic poliomyelitis. However, the annual incidence of polio fell exponentially beginning in 1955, resulting in the elimination of the virus across the country in 1979.[128]

It took many years to recognize poliomyelitis as a disease-causing paralysis and permanent disability. It was the twentieth-century poliomyelitis epidemics when scientific research worked to understand the disease's nature and its biological and epidemiological characteristics began. This was also a period of acute fear and uncertainty around poliomyelitis among the general public. The scientists were determined in the environment of fear to defeat the disease. However, it took many years for the scientists to generate the knowledge required to understand poliovirus's nature and its vaccine. The delays in solving a significant public health problem of that time and the growing fear among the people put pressure on the governments and scientists. This momentum was built to finally, the hard work of several scientists led to the possibility of preventing the disability caused by poliomyelitis. The

[127] Blume, S. & Geesink, I. (2000). Essay on Science And Society: A Brief History of Polio Vaccines. *Science,* 288(5471), 1593 – 1594; Offit, A. P. (2005). *The Cutter Incident: How America's First Polio Vaccine Led to the Growing Vaccine Crisis*. New Haven: Yale University Press.

[128] Blume, S. & Geesink, I. (2000). Essay on Science And Society: A Brief History of Polio Vaccines. *Science,* 288(5471), 1593 – 1594; Oshinsky, D.M. (2005). *Polio: An American Story*. New York: Oxford University Press; Paul, J, R. (1971). *A history of Poliomyelitis, Yale studies in the history and medicine.* New Haven and London: Yale University Press; Nathanson, N., & Kew, M. O. (2010). From Emergence to Eradication: The Epidemiology of Poliomyelitis Deconstructed. *American Journal of Epidemiology*, 172, 1213–1229.

availability of vaccines as a simple, low-cost solution to the polio problem resulted in the elimination of poliovirus in the 1960s and 1970s from a few high-income countries using only IPV and other countries using OPV.

The optimism toward a vision of a polio-free world and set goals for its eradication became possible only with the discovery of polio vaccines. Polio became a vaccine-preventable disease with the discovery and use of two polio vaccines - an inactivated (killed) inject-table polio vaccine (IPV) by Dr Jonas Salk available in the US from 1954 to 1955 and a live attenuated (weakened) oral polio vaccine (OPV) by Dr Albert Sabin in available in the US from 1961 -1962. However, the many apprehensions and doubts among the scientists, public and policymakers on Salk's vs Sabin vaccines remained live even today.

3. DIFFUSION OF POLIO ERADICATION INITIATIVE IN DEVELOPING REGION

Endemic Disease to A Global Problem

The discovery of the polio vaccine against poliomyelitis was a victory against the paralyzing disease in countries that were experiencing the reoccurring epidemic for a more extended period. However, it also opened the gates for complete victory over an infectious disease. The discovery of vaccines made the elimination of poliovirus from the environment feasible. Polio vaccine opened the paths for complete eradication of polio from the society of humans as it was achieved with smallpox disease. As the vaccine became widely available many industrialized countries experiencing severe epidemics started using it on a mass scale. However, the pursuit of promoting the polio vaccine in non-epidemic countries was taken as a social responsibility for ensuring global equity and preventing the resurgence of polio epidemics in industrialized countries. As the worldwide commitment was made to eradicate the poliovirus from the earth, it did not take much time for countries of the South to adopt the idea of polio eradication and subsequently start nationwide polio immunization campaign.

3.1 Endemic and Epidemic Character of Polio

Geographical, poliomyelitis was considered widespread in the temperate and tropical regions of the world. Before the nineteenth century, the disease was endemic, and since 1900, it has been regarded as omnipresent with its worldwide distribution with its typical symptoms causing paralysis.[129] However, in the temperate region countries, there were two epidemiological transitions by the twentieth century – 1) The endemic disease changed to

[129] teething", " foul bowels", or a "fever" (Paul, J, R. (1971). *A history of Poliomyelitis, Yale studies in the history and medicine.* New Haven and London: Yale University Press; Paul, J, R.(1955). *Epidemiology of poliomyelitis. In: Poliomyelitis.* Geneva: World Health Organization: Monograph Series, 26. (Retrieved from www.who.int))

periodically recurring epidemic form of clinically recognizable characteristics and as a highly infectious disease; 2) There was an unusual increase in age incidence from infantile paralysis diseases commonly occurring in infants to affecting the high age children and even adults. This pattern of epidemiological transition, like the diseases, was not seen in tropical regions. Most tropical countries were unaffected by this transition and were experiencing it before the nineteenth-century epidemiological pattern of disease. The disease was considered mildly contagious or infectious and not a major medical problem.[130]

A series of outbreaks of poliomyelitis beginning in 1880 reported from Scandinavian countries and the United States and simultaneously from Europe were isolated cases in the twentieth century. A sudden surge in polio cases with frequent and serve epidemics were not reported from the rest of the world. [131]

Tropical countries experience freedom from the epidemic form of polio for a very long period. The idea that the disease is not prevalent in tropical countries was considered, and outbreaks seen in the temperate region are due to a new disease or the introduction of a new strain of virus into the community. However, such overgeneralized idea was far from the reality as in many countries endemic nature of polio was highly prevalent, and polio cases sporadically occurred. The endemic character of the polio was relieved in the tropical country when army

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[130] Paul, J, R. (1971). *A history of Poliomyelitis, Yale studies in the history and medicine.* New Haven and London: Yale University Press; Paul, J, R.(1955). *Epidemiology of poliomyelitis. In: Poliomyelitis.* Geneva: World Health Organization: Monograph Series, 26. (Retrieved from www.who.int); Rhodes, A. J. (1948). The geographical incidence of poliomyelitis with special reference to some features of the disease in the tropics. *In: Proceedings of the Fourth International Congresses on Tropical Medicine and Malaria*,1, 536; Gear, J. (1955). *Poliomyelitis in the under-developed areas of the world:* In: *Poliomyelitis*. Geneva: World Health Organization: Monograph Series, 26. (Retrieved from www.who.int)

[131] Smallman-Raynor, M., Smallman-Raynor, M.R., Cliff, A.D. (2006). *Poliomyelitis: Emergence to Eradication, Oxford Geographical and Environmental Studies*. Oxford and New York: Oxford University Press; Paul, J, R. (1971). *A history of Poliomyelitis, Yale studies in the history and medicine.* New Haven and London: Yale University Press; Paul, J, R.(1955). *Epidemiology of poliomyelitis. In: Poliomyelitis.* Geneva: World Health Organization: Monograph Series, 26. (Retrieved from www.who.int)

soldiers during the World Wars entered the tropical regions. Unlikely the polio infection attacked the military units in more significant numbers than the native population of tropical countries where the disease did not appear to be prevalent. The occurrence of higher rates of polio infection among military units in higher age groups was different from lower age groups in their native places. The incidence of polio infection among soldiers also established that polio persisted across populations worldwide and was not a rare disease in the tropics.[132]

One of the significant prominent explanations for the epidemiological transition was polio disease spread from tropical to temperate countries. Believing polio is a tropical disease also establishes the idea that the polio epidemic in temperate regions was exported from tropical areas in summers of temperate regions due to migration of infection. However, this explanation was disregarded as the worldwide distribution of poliomyelitis was already known even before the epidemic nature of diseases started.[133]

The geographical scope of the disease increased only after the middle of the twentieth century when polio became a public health threat in developing countries. Over time the severity of polio epidemics increased outside of industrialized countries with improved reporting. Countries which were considered polio-free previously started showing the trend of

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[132] Polio cases among military units were reported in 1936 in Philippine Islands and during the second World War. Also, cases were reported from India, China, Korea, Japan, Middle East.
(Paul, J, R.(1955). *Epidemiology of poliomyelitis. In: Poliomyelitis.* Geneva: World Health Organization: Monograph Series, 26. (Retrieved from www.who.int); Rhodes, A. J. (1948). The geographical incidence of poliomyelitis with special reference to some features of the disease in the tropics. *In: Proceedings of the Fourth International Congresses on Tropical Medicine and Malaria*,1, 536; Gear, J. (1955). *Poliomyelitis in the under-developed areas of the world:* In *Poliomyelitis*. Geneva: World Health Organization: Monograph Series, 26. (Retrieved from www.who.int); Paul, J, R. (1971). *A history of Poliomyelitis, Yale studies in the history and medicine.* New Haven and London: Yale University Press; Paul, J, R., Havens, W.P., & Rooyen, C.E.V. (1994). Poliomyelitis In British And American Troops In The Middle East The Isolation Of Virus From Human Faeces. *British Medical Journal,* 1(4355): 841-843.

[133] Gear, J. (1955). *Poliomyelitis in the under-developed areas of the world:* In *Poliomyelitis*. Geneva: World Health Organization: Monograph Series, 26. (Retrieved from www.who.int); Paul, J, R.(1955). *Epidemiology of poliomyelitis. In: Poliomyelitis.* Geneva: World Health Organization: Monograph Series, 26. (Retrieved from www.who.int); Paul, J, R. (1971). *A history of Poliomyelitis, Yale studies in the history and medicine.* New Haven and London: Yale University Press.

increasing incidence. By the middle of the twentieth century, the severity of polio increased in Africa, with large epidemics reported in its various regions. A similar transition from endemic to the epidemic was also seen in Asia, the Middle East and Latin America.[134]

Since 1955 interest in measuring the incidence of polio cases in underdeveloped countries was developed within WHO. A series of comprehensive surveys confirmed that the increasing incidence of polio is not merely an isolated occurrence in developed countries or temperate regions. But polio is becoming a severe problem with the increased epidemics in underdeveloped countries.[135]

Unlike in temperate regions in underdeveloped regions, the seasonality of increase in polio cases was not determined by season and was considered to occur at any time during the year. Similarly, an increasing incidence of polio cases es reported mainly in children under five. However, mostly peak incidence of polio occurs in rainy seasons.[136]

3.2 Polio a Problem of Civilization

The public health measures of nineteenth century improved the environment and sanitation in developed countries to a considerable level reducing mortality and morbidity.

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[134] Gear, J. (1955). *Poliomyelitis in the under-developed areas of the world:* In: *Poliomyelitis*. Geneva: World Health Organization: Monograph Series, 26. (Retrieved from www.who.int); Paul, J, R.(1955). *Epidemiology of poliomyelitis. In: Poliomyelitis.* Geneva: World Health Organization: Monograph Series, 26. (Retrieved from www.who.int); Paul, J, R. (1971). *A history of Poliomyelitis, Yale studies in the history and medicine.* New Haven and London: Yale University Press.

[135] Gear, J. (1955). *Poliomyelitis in the under-developed areas of the world:* In: *Poliomyelitis*. Geneva: World Health Organization: Monograph Series, 26. (Retrieved from www.who.int); Freyche, J.M., Payne, M.M.A., & Lederrey, C. (1955). Poliomyelitis in 1953. *Bulletin of the World Health Organization*, 12,595-649.

[136] Gear, J. (1955). *Poliomyelitis in the under-developed areas of the world:* In: *Poliomyelitis*. Geneva: World Health Organization: Monograph Series, 26. (Retrieved from www.who.int); Paul, J, R.(1955). *Epidemiology of poliomyelitis. In: Poliomyelitis.* Geneva: World Health Organization: Monograph Series, 26. (Retrieved from www.who.int)

There was an unusual epidemiological transition of the poliomyelitis in developed countries, and the developing countries in the tropical region were unaffected.

It was puzzling for the scientists to understand how the outbreaks of poliomyelitis occur in the environment of advanced sanitary public health measures in the west. It was considered essential to resolve this paradoxical difference in polio disease between developing countries and developed countries.

Explaining the transition of the disease was essential to understand the factors or mechanisms that allow the transition of sporadic polio to epidemic poliomyelitis and predict such transition in underdeveloped countries. It was necessary for future public health measures, which could be expensive for developing countries. Measuring the degree to which environmental sanitation facilitates the epidemic was essential to explain the possible epidemic form of poliomyelitis in the tropical region and the need for control measures.[137]

In the quest to answer this epidemiological transition, various studies were conducted, and explanations were discussed among the scientist at the International Poliomyelitis Conferences.[138]

One of the primary explanations for the endemic character of poliovirus among children in developing countries was immunity acquired in early life due to exposure to poliovirus.

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[137] Paul, J.R. (1958). Endemic and epidemic trends of poliomyelitis in Central and South America. *Bulletin of the World Health Organization*, 19,747-758.

[138] Paul, J.R. (1958). Endemic and epidemic trends of poliomyelitis in Central and South America. *Bulletin of the World Health Organization*, 19,747-758; Payne, A. M. M. (1955). Poliomyelitis as a world problem. In: *Poliomyelitis: Papers and discussions presented at the Third International Poliomyelitis Conference*, 393-400; Sabin, A.B. (1951). Paralytic Consequences of Poliomyelitis Infection in Different Parts of the World and in Different Population Groups. *American Journal of Public Health*, 41(10), 215-1230.

Two explanations were given for immunity against poliovirus among children in developing countries. Active immunity against poliovirus was already acquired among children of developing countries through exposure to subclinical or minor polio infections due to prevalent in poor sanitary conditions of underdeveloped areas. Maternal antibodies develop partially passive immunity among children. Thus, latent immunization was considered responsible for relative immunity, and lack of greater susceptibility reduced the risk of developing paralytic polio among children in developing countries.[139]

The epidemic nature of polio in industrialized countries resulted from the rise in living standards and high sanitation standards. Children in developed countries have limited chances of polio infection exposure early in life. Thus, many children in these countries do not acquire immunity against polio infection. On the other hand, children in developing countries living in crowded and poor conditions and with primitive sanitation get an opportunity to develop immunity against poliovirus very early in life. The primitive standards of living facilitated the spread of poliovirus more easily, immunizing a large percentage of children. Polio infection, largely prevalent, did not get a large group of suspectable populations to emerge in epidemic character.[140]

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[139] Paul, J.R. (1958). Endemic and epidemic trends of poliomyelitis in Central and South America. *Bulletin of the World Health Organization*, 19,747-758; Payne, A. M. M. (1955). Poliomyelitis as a world problem. In*: Poliomyelitis: Papers and discussions presented at the Third International Poliomyelitis Conference*, 393-400; Sabin, A. B. (1948). Epidemiologic patterns of poliomyelitis in different parts of the world. In: *International Poliomyelitis Congress, Poliomyelitis: papers and discussions presented at the First International Poliomyelitis Conferences*, p3; Sabin, A.B. (1955). *Immunity in poliomyelitis, with special reference to vaccination*. In: *Poliomyelitis.* Geneva: World Health Organization: Monograph Series, 26.

[140]Sabin, A.B. (1955). *Immunity in poliomyelitis, with special reference to vaccination*. In: *Poliomyelitis* Geneva: World Health Organization: Monograph Series, 26; Payne, A. M. M. (1955). Poliomyelitis as a world problem. *In: Poliomyelitis: Papers and discussions presented at the Third International Poliomyelitis Conference*, 393-400; Paul, J.R. (1958). Endemic and epidemic trends of poliomyelitis in Central and South America. *Bulletin of the World Health Organization*, 19,747-758; Gear, J. (1955). *Poliomyelitis in the under-developed areas of the world:* In: *Poliomyelitis*. Geneva: World Health Organization: Monograph Series, 26. (Retrieved from www.who.int); Sabin, A. B. (1948). Epidemiologic patterns of poliomyelitis in different parts of the world. In: *International Poliomyelitis Congress, Poliomyelitis: papers and discussions presented at the*

It was challenging to measure the sanitation levels of countries, so as a proxy, infant mortality was measured to understand the degree of sanitation and its correlation with infant mortality. Pioneering research was done by a member of the world health organization proposing the explanation of infant mortality and its inverse relation between infant mortality rates and the low reported incidence of poliomyelitis case rates reported in some parts of the world. [141]

This inverse relationship was again studied in Latin American underdeveloped regions. It was estimated that polio incidence is related to countries with poor living conditions. Compared to developed countries, in underdeveloped countries, the incidence increases when living conditions improve, and infant mortality rates decrease to below 75 per 1000 live births.[142]

It was considered that the improvement in the "way of life" population of Africa, Asia and Latin America could transition from the endemic character of polio disease to an epidemic.[143]

Throughout the world review of epidemiological patterns of poliomyelitis was noted by Sabin to varied across populations in his paper. It was evident that the risk of paralytic

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First International Poliomyelitis Conferences, 3; Paul, J, R.(1955). *Epidemiology of poliomyelitis. In: Poliomyelitis.* Geneva: World Health Organization: Monograph Series, 26. (Retrieved from www.who.int)

[141] Payne, A. M. M. (1955). Poliomyelitis as a world problem. *In: Poliomyelitis: Papers and discussions presented at the Third International Poliomyelitis Conference*, 393-400.

[142] Paul, J.R. (1958). Endemic and epidemic trends of poliomyelitis in Central and South America. *Bulletin of the World Health Organization*, 19,747-758

[143] Gear, J. (1955). *Poliomyelitis in the under-developed areas of the world:* In: *Poliomyelitis*. Geneva: World Health Organization: Monograph Series, 26. (Retrieved from www.who.int); Paul, J, R.(1955). *Epidemiology of poliomyelitis.* In: *Poliomyelitis.* Geneva: World Health Organization: Monograph Series, 26. (Retrieved from www.who.int)

poliomyelitis infection showed a remarkable difference for people living in different regions of the world. [144]

He argued that the against the passive latent immunization among young children and consequently the low incidence of paralytic polio in developing countries-

"The low incidence of paralytic poliomyelitis, even among the children of the Far East, Africa, and certain other primitive population groups, at a time when virulent virus is known to be in their midst, as indicated by the high attack rates among adult foreigners in their midst, cannot be attributed to subclinical immunization of infants under the influence of either placentally or milk-transmitted antibody, because serological surveys have revealed that 80 to 90 per cent are still without antibody at the end of the first or second year of life. Serological surveys furthermore have brought forth more than suggestive evidence that the incidence of paralytic poliomyelitis is inversely proportional to the extensiveness of viral dissemination. In general, the poorer the population, its standard of living and sanitation, the more extensively is poliomyelitis virus disseminated among them and the lower is the incidence of paralytic poliomyelitis when virulent strains of virus come their way." pg. 1228 1229[145]

It established the evidence for some time on sanitation and poor living conditions as key factors explaining the transition of polio disease in developed countries. Debates on the latent passive immunity among children of underdeveloped countries against poliovirus continued and intensified when the polio vaccine was widely available. Lameness surveys further challenged the silent immunity of young children in developing countries.

3.3 Estimating Poliomyelitis Actual Incidence in Developing Countries

In public health, estimating the actual annual incidence of the disease is essential for planning public health interventions and their funding. Estimating the incidence and virus types of polio in the world was essential not only to understand the polio virus sources but also to determine the accountability of outbreaks.

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[144] Sabin, A. B. (1948). Epidemiologic patterns of poliomyelitis in different parts of the world. In: *International Poliomyelitis Congress, Poliomyelitis: papers and discussions presented at the First International Poliomyelitis Conferences*, 3.

[145] Sabin, A.B. (1955). *Immunity in poliomyelitis, with special reference to vaccination*. In: *Poliomyelitis* Geneva: World Health Organization: Monograph Series, 26.

Efforts to discuss and report findings on the worldwide distribution of the polio incidence and its epidemiological pattern started with the First International Conference on Poliomyelitis in 1948.[146]

There were significant concerns about the incidence and prevalence of polio in endemic regions and the efficacy of the polio vaccine. Estimating the incidence of poliomyelitis in underdeveloped countries settled many of these concerns and made an insignificant polio problem in underdeveloped countries significant for sub-tropical and tropical countries for contemplating vaccination programs.

Since the start of the poliomyelitis epidemic in developed countries, there has been no debate on the worldwide distribution of polio disease. Many studies were conducted to understand the types of polioviruses and incidence in both developed and developing countries. In their periodicals, much of the insight into the worldwide situation on poliomyelitis incidence was reported by the League of Nations Health Organization and by the World Health Organization.[147]

The polio incidence was also reported by the studies conducted in countries using the official statistics. However, many cases in countries' official statistics did not report the polio incidence data. Studies conducted on polio incidence were sufficiently lacking in reliable data as, in many cases, data was provisional or approximate, or the source was unpublished. Polio data compilation and accuracy of data collected from countries were questionable. The significant estimates of the worldwide distribution of the polio incidence were insufficient to make the

[146] Sabin, A. B. (1948). Epidemiologic patterns of poliomyelitis in different parts of the world. In: *International Poliomyelitis Congress, Poliomyelitis: papers and discussions presented at the First International Poliomyelitis Conferences*, 3.

[147] Freyche, J.M., Payne, M.M.A., & Lederrey, C. (1955). Poliomyelitis in 1953. *Bulletin of the World Health Organization*, 12,595-649.

correct conclusion on the incidence of polio in a country.[148] The problem of reporting polio from across the countries was discussed in the WHO report in 1955 -

"we are justified in attempting to apply statistical analysis to the official figures available on cases of poliomyelitis and deaths due to this disease in the various countries of the world. However, the inherent difficulty of such an undertaking is obvious. In certain countries, only cases of the acute paralytic form of the complaint are registered under the heading of" poliomyelitis"…… Elsewhere, notifications also cover a varying proportion of febrile states with signs of meningeal irritation, without symptoms of spinal or bulbar paralysis, and perhaps abortive forms without manifestations which can be ascribed to involvement of the central nervous system. In such cases a clinical diagnosis can only be one of probability, even when it refers to patients who have been in close contact ·with a confirmed case of poliomyelitis, and the possibility of error is very large. However, in view of the practical impossibility of any laboratory confirmation, it is probable that the immense majority of such clinical cases are not notified to the health authorities. The same applies in even stronger measure to the innumerable asymptomatic infections, which escape all medical control…… For most countries no information is available, and for many others the information existing must be treated with caution." pg. 59 & 60[149]

The year 1953 was a critical year setting the stage for international efforts against polio and bringing to light the issue at the global level. Before the global commitment to polio eradication, the World Health Organization (WHO) put in efforts at the global level to promote the oral polio vaccine and polio immunization program.[150] The WHO started taking polio as a significant public health problem worldwide. To the world health organization –

"The transformation of the relatively uncommon infantile paralyses of the 19th century into 'epidemic poliomyelitis' of almost worldwide distribution presents today one of the most formidable public-health problems." pg. 3[151]

[148] Freyche, J.M., Payne, M.M.A., & Lederrey, C. (1955). Poliomyelitis in 1953. *Bulletin of the World Health Organization*, 12,595-649.

[149] Freyche, J.M., Payne, M.M.A., & Lederrey, C. (1955). Poliomyelitis in 1953. *Bulletin of the World Health Organization*, 12,595-649.

[150] Freyche, J.M., Payne, M.M.A., & Lederrey, C. (1955). Poliomyelitis in 1953. *Bulletin of the World Health Organization*, 12,595-649.

[151] World Health Organization. (1954). *Expert Committee on Poliomyelitis: First Report*. World Health Organization Technical Report Series No. 81, Switzerland. (Retrieved from www.who.int)

Reporting incidence of polio was started by the WHO started in 1951. By 1953 it was assumed that all three types of polioviruses were widely distributed worldwide. There were reported cases of the rising incidence of polio in developing countries of Africa- Anglo, Egypt primarily due to improved reporting. Simultaneously there was a reported decrease in the incidence of polio in many countries, including India.[152] However, available data from Asiatic countries was largely incomplete.[153]

3.4 Polio is Significantly a Problem in Developing Countries

Over the past two decades before the launch, the global commitment to eradicate polio gradually increased the world's attention to the polio disease, which set the future global efforts for polio eradication.

It was not until the 1970s that the problem of polio became a significant problem in developing countries. Before this period, it was relatively insignificant for the underdeveloped developing countries dealing with other diseases.

Estimating the current incidence of paralytic poliomyelitis in different economically undeveloped countries was the first essential step in promoting the polio vaccine and planning an immunization program. Because of the limited official data, the actual estimated incidence of paralytic poliomyelitis remained unknown in developing countries.

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[152] Marked decrease in incidence of polio reported by 1953 in Africa-Kenya, Mauritius, Southem Rhodesia, and Uganda; America-Chile (probably), Cuba, and the USA; Asia- Cambodia, Ceylon, India, Israel (Freyche, J.M., Payne, M.M.A., & Lederrey, C. (1955). Poliomyelitis in 1953. *Bulletin of the World Health Organization*, 12,595-649)

[153] Freyche, J.M., Payne, M.M.A., & Lederrey, C. (1955). Poliomyelitis in 1953. *Bulletin of the World Health Organization*, 12,595-649.

The official data on incidence was widely varied in different countries, insufficient, underreported and incomplete in the underdeveloped health services of developing countries. In 1969 the twenty-second World Health Assembly reviewed the problem of paralytic polio along with louse-borne typhus, louse-borne relapsing fever, and viral influenza worldwide.

> "Considering that poliomyelitis epidemics occur frequently in areas where the child population has not been thoroughly vaccinated and that the immune status of populations is constantly changing, especially in developing countries, owing to urbanization and other population movements; and" pg. 32[154]

The WHA recognized the importance of disease surveillance programmes for speedy information on approaching outbreaks. They have asked its member countries' health administrations to promptly report complete epidemiological data on polio regularly and inform the organization of any outbreaks within their country regions. It was the year in which Health Assembly adopted International Health Regulations, which were later amended.[155] Since 1970 WHO also started publishing an annual summary of polio status worldwide in its *Weekly Epidemiological Record.*

Discussion on the continued and higher increasing trend in the incidence of disease in several countries in developing countries started in the 1970s. Various estimates were published on polio becoming a significant problem in developing regions.[156] The rising trend in polio incidence in Africa requires accurately estimating the magnitude of the polio problem

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[154] World Health Organization. (1969). *Twenty-Second World Health Assembly*: *Part I: Resolutions and Decisions: Annexes.* Boston, Massachusetts. (Retrieved from www.who.int)

[155] World Health Organization. (1969). *Twenty-Second World Health Assembly*: *Part I: Resolutions and Decisions: Annexes.* Boston, Massachusetts. (Retrieved from www.who.int)

[156] Assaad, F., & Ljungars-Esteves, K. (1984). World Overview of Poliomyelitis: Regional Patterns and Trends. *Reviews of Infectious Diseases*,6(2); Cockburn, W.C., & Drozdov, S.G., (1970). Poliomyelitis in the world. *Bulletin of the World Health Organization*, 42, 405-17; International Symposium on Poliomyelitis Control. (1984). *Review of Infectious Diseases*, 6, S302-S307.

in different developing countries. This created demand for clinical surveys[157] to accurately estimate the polio incidence it was deemed necessary to prevent and control polio in developing countries.

The Lameness survey in Ghana challenged the widely held explanation for the emergence of epidemic polio in societies due to the increased standards of lifestyle and sanitation given for the endemicity of polio in developing countries.

In 1977 Nicholas et al. published a paper article emphasizing the growing problem of polio in developing countries among children of rural Ghana and the prioritization of polio immunization for this region. Lameness surveys were conducted in 1974 in districts under the Danfa Project of rural Ghana to study the impact of endemic polio in the rural districts. It was widely accepted that paralytic poliomyelitis occurs in less than 1 per 1000 children among children in districts of Ghana. Through lameness assessment among children in rural Ghana, it was estimated that the annual incidence of polio was 28 per 100,000. The prevalence of polio was found to be 7 per 1000 school-aged children. This contradicted the earlier held belief that paralytic poliomyelitis is a relative rarity in Ghana. Rates of polio incidence and prevalence reported in Ghana's rural districts were comparable to those reported in developed countries of the USA and Europe during epidemic years.[158]

The estimates on polio incidence refuted the generally held idea that polio is not an actual problem in underdeveloped regions. Demand for more accurate data from other developing regions on polio increased. Following the demand, more than 100 lameness surveys

[157] Many serological surveys reported extend of infection of polioviruses in endemic countries. But these surveys were considered limited for the purpose to understand the actual incidence of paralytic poliomyelitis.

[158] Nicholas, D. D., Kratzer, J.H., Ofosu-Amaah, S., Belcher, D.W. (1977). Is poliomyelitis a serious problem in developing countries? the Danfa experience. *British Medical Journal*, 1, 1009-1012.

were conducted in 1974, starting in Ghana, Burma, Egypt and the Philippines. The lameness surveys focused on residual paralysis to estimate the average incidence of paralytic poliomyelitis. These surveys were the most straightforward procedure to implement by observing the clinical features of residual paralysis in school children in urban and rural districts by school teachers.[159] The Ghana model was particularly peculiar and was taken as a model for other countries. Using the model in Ghana, a series of lameness surveys were conducted in many other developing countries to understand the magnitude of the polio problem. The Ghana survey design provided an excellent model to compare the clinical surveys across countries for estimating the incidence of paralytic poliomyelitis in developed countries.[160] The WHO developed the standards and protocols for reporting the lameness survey.[161]

Lameness surveys were considered beneficial to provide data on the realistic magnitude of paralytic poliomyelitis in undeveloped countries. This realistic data on the actual incidence of polio was considered necessary for countries planning an effective polio vaccination program. It estimated the actual prevalence rates, ranging from less than 1 to as high as 25 per 1000 children.[162]

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[159] International Symposium on Poliomyelitis Control. (1984). *Review of Infectious Diseases,* 6, S302-S307; Sabin, A.B. (1980). Vaccination Against Poliomyelitis in Economically Underdeveloped Countries. *Bulletin of the World Health Organization*, 58(1), 141-157; Bernier, R. H. (1984). Some observations on Poliomyelitis Lameness Surveys. *Reviews of Infectious Diseases*,6(2), S371-5.

[160] Nicholas, D. D., Kratzer, J.H., Ofosu-Amaah, S., Belcher, D.W. (1977). Is poliomyelitis a serious problem in developing countries? the Danfa experience. *British Medical Journal*, 1, 1009-1012.

[161] LaForce, F.M., Lichnevski, M.S., Keja, J., & Henderson, R.H. (1980). Clinical Survey Techniques to Estimate Prevalence and Annual Incidence of Poliomyelitis in Developing Countries. *Bulletin of the World Health Organization,* 58:609-20.

[162] Bernier, R. H. (1984). Some observations on Poliomyelitis Lameness Surveys. *Reviews of Infectious Diseases*,6(2), S371-5; International Symposium on Poliomyelitis Control. (1984). *Review of Infectious Diseases,* 6, S302-S307.

These lameness surveys revealed that in the subtropical and tropical regions of the world, poliovirus spread widely throughout the year. It pushed aside the hypothesis of the high standard of sanitation relationship with polio incidence and an inverse relationship with infant mortality.

Lameness surveys established that the main challenge for control of poliomyelitis in the 1980s was subtropical and tropical regions of the world. It redefined the polio disease in under-developed areas of the world from the sporadic endemic polio incidence to the epidemic nature of considerable significance. These lameness surveys revealed the age group in which the paralytic poliomyelitis cases start in developing countries. Knowing the actual age group was essential for planning maximum vaccination coverage; consequently, many countries started polio vaccination programs.[163]

It revealed the differences in the pattern of the epidemiology of poliomyelitis between temperate and tropical regions. It answers the critical question that the world was puzzling to answer: why endemic polio disease transit to the frequent epidemics in the western, highly sanitized world. One of the essential differences revealed was that those differences in epidemics of well-developed countries from developing countries were not much of the concern of incidence but age distribution. In a developing country, the endemic or hyperendemic polio occurs mainly in children at young age group children. Endemic poliomyelitis exposed the majority (90 per cent) of the infants under five years of age to infection very early in life-giving them the opportunity to develop antibodies against the disease. In temperate, highly sanitized developed countries, this opportunity for exposure to

[163] Sabin, A.B. (1980). Vaccination Against Poliomyelitis in Economically Underdeveloped Countries. *Bulletin of the World Health Organization*, 58(1), 141-157; Nicholas, D. D., Kratzer, J.H., Ofosu-Amaah, S., Belcher, D.W. (1977). Is poliomyelitis a serious problem in developing countries? the Danfa experience. *British Medical Journal*, 1, 1009-1012.

poliovirus and developing antibodies were limited in early life. Thus, the children of the under-five age group who escaped the infection were suspectable of polio infection in the adult and older age group. In developed regions where the infection was absent for generation of older and adult age group's introduction of an invasive strain of poliomyelitis virus results in an epidemic of polio of great intensity. The severity and frequency of polio were more intense in adults and older age groups than in infants of one to five years of age.[164]

The surveys made the minor polio problem in subtropical and tropical countries of underdeveloped regions relatively significant for consideration and planning for the vaccination programs. Sabin pushed further the significance of conducting these lameness surveys in underdeveloped countries and the significance of its data. In 1962 Sabin drew attention to the increased incidence of paralytic polio in the past ten years in many tropical countries of America, Africa and Asia limited to children under three years of age. Dr Sabin stated that the paralytic poliomyelitis rates were increasing without any improvement in living standards and very high infant mortality rates.[165]

For Dr Sabin, eradicating worldwide polio was essential and of more concern in the economically undeveloped countries in subtropical and tropical regions. In the 1980s, after the estimates from the Lameness survey, the theory of sanitation and infant mortality was

[164] Sabin, A.B. (1980). Vaccination Against Poliomyelitis in Economically Underdeveloped Countries. *Bulletin of the World Health Organization*, 58(1), 141-157; Bernier, R. H. (1984). Some observations on Poliomyelitis Lameness Surveys. *Reviews of Infectious Diseases*,6(2), S371-5; International Symposium on Poliomyelitis Control. (1984). *Review of Infectious Diseases,* 6, S302-S307; Paul, J, R.(1955). *Epidemiology of poliomyelitis. In: Poliomyelitis.* Geneva: World Health Organization: Monograph Series, 26. (Retrieved from www.who.int)

[165] Sabin, A. B. (1963). Poliomyelitis in the tropics-increasing incidence and prospects for control. *Tropical and Geographical Medicine*, 15: 38-44.

challenged by Dr Sabin considered this dogma and drew attention to the world once again to the rising disease incidence in developing countries.[166]

Increased reporting of polio incidence and the Lameness survey settled much of the concern on the actual incidence and prevalence of polio in endemic regions. The surveys made the minor polio problem in subtropical and tropical countries of underdeveloped regions relatively significant for consideration and planning for the vaccination program.

3.5 The Legacy of Smallpox

Smallpox disease for almost three thousand years, troubled the human population. Since Jenner's discovery of the smallpox vaccine in 1796, efforts to immunization moved very slow until mid of the 1960s

"DECLARES SOLEMNLY THAT THE WORLD AND ALL ITS PEOPLES HAVE WON FREEDOM FROM SMALLPDX, WHICH WAS A MOST DEVASTATING DISEASE SWEEPING IN EPIDEMIC FORM THROUGH MANY COUNTRIES SINCE EARLIEST TIMES, LEAVING DEATH, BLINDNESS AND DISFIGUREMENT IN ITS WAKE, AND WHICH ONLY A DECADE AGO WAS RAMPANT IN AFRICA, ASIA AND SOUTH AMERICA" pg. 1[167]

It almost took 200 years for the international health community, from Jenner's discovery to and elimination of the smallpox virus from the earth in 1980. The World Health Assembly's commitment to the worldwide eradication of smallpox in 1959 did not come easily. Compared to the malaria eradication program, smallpox eradication was far more feasible technically and less costly. However, within the World Health Assembly, there were

[166] Sabin, A.B. (1980). Vaccination Against Poliomyelitis in Economically Underdeveloped Countries. *Bulletin of the World Health Organization*, 58(1), 141-157.
[167] World Health Organization. (1980). *Thirty-Third World Health Assembly: Resolutions and Decisions Annexes.* Geneva, WHA33/1980/REC/1. (Retrieved from www.who.int)

apprehensions and skepticism about setting the goal of eradicating smallpox for a very long time.

Inspired by the regional smallpox eradication program in the Americas, the first Director-General, Dr Brock Chisholm, proposed the goal of smallpox campaigns first in February 1953 to the eleventh session of the Executive Board in his report "Further action on general world health problems".[168] Later in the 1953 Sixth World Health Assembly in May, Dr Chisholm proposed the World-Wide Campaign against Smallpox.[169] Calling Health Assembly to expand its advisory services in countries and visualize truly international coordinated programmes in all its member states to improve the general health condition. It would increase the significance of WHO in its member states through international collaborative action.[170] After two years of studying the estimated cost and plan of action for initiating the worldwide smallpox campaign by WHO. At the Eight, the World Health Assembly in May 1955 only urged its member to conduct smallpox campaigns considering the local needs.

"URGES again that health administrations conduct, wherever necessary, campaigns against smallpox as an integral part of their public -health programmes." pg. 39 [171]

[168] World Health Organization. (1954). *Executive Board Eleventh Session: Resolutions Report Of The Executive Board Including The Report On The Proposed Programme And Budget Estimates For 1954 Annexes*. Geneva, No. 46. (Retrieved from www.who.int)

[169] World Health Organization (WHO). (1953). *Sixth World Health Assembly: Resolutions and Decisions Plenary Meetings Verbatim Records Committees Minutes and Reports International Sanitary Regulations Reservations: Overseas And Outlying Territories Annexes.* Geneva, No. 48. (Retrieved from www.who.int)

[170] World Health Organization. (1954). *Executive Board Eleventh Session: Resolutions Report Of The Executive Board Including The Report On The Proposed Programme And Budget Estimates For 1954 Annexes*. Geneva, No. 46. (Retrieved from www.who.int); Fenner, F., Henderson, D.A., Arita, I., Jezek, Z., & Ladnyi, I. D. (1988). *Smallpox and its Eradication*. Geneva: World Health Organization.

[171] World Health Organization. (1955). *Eight World Health Assembly: Resolutions and Decisions Plenary Meetings Verbatim Records Committees Minutes and Reports Annexes*. Geneva, No. 63. (Retrieved from www.who.int)

Reluctance for the proposal of smallpox campaigns was expressed strongly by members of states from several countries, including the then Director-General, Dr Marcolino Candau, in 1954. The campaign was considered needless and uneconomical. The smallpox disease problem was viewed as a local regional level problem without international support. Members of states considered the need for a global malaria eradication program far more critical than smallpox eradication.[172]

After five years, the proposal for a smallpox eradication campaign was again introduced at the Eleventh Health Assembly in 1958.[173] However, this time it was introduced by the USSR Deputy Minister of Health Victor Zhdanov and members of the Assembly. Professor Zhdanov was a great proponent of the eradication program as a Chief of the Department of Sanitary and Epidemiological Services at communicable disease control in the USSR. It was inspired by the successful interruption of smallpox transmission in 1936 in the USSR and dracunculiasis elimination in Central Asian republics of the USSR in 1932. Professor Zhdanov considered the eradication concept as a cost-effective strategy to achieve results in a short time using fewer resources. Smallpox was a feasible program considering the importation of disease from endemic and non-endemic countries was a continued problem in the USSR, adding additional cost to the country's health budget. Thus, its complete eradication worldwide in the next ten years was the proposal made to the World Health Assembly in 1958.[174] Against the long

[172] Fenner, F., Henderson, D.A., Arita, I., Jezek, Z., & Ladnyi, I. D. (1988). *Smallpox and its Eradication*. Geneva: World Health Organization.

[173]World Health Organization. (1958). *Eleventh World Health Assembly: Resolutions and Decisions Plenary Meetings Verbatim Records Committees Minutes and Reports Annexes*. Geneva, No.87. (Retrieved from www.who.int)

[174]Fenner, F., Henderson, D.A., Arita, I., Jezek, Z., & Ladnyi, I. D. (1988). *Smallpox and its Eradication*. Geneva: World Health Organization; Henderson, D.A. (2011). The Eradication of Smallpox – An Overview of the Past, Present, and Future. *Vaccine*, 29S D7-D9; World Health Organization. (1958). *Eleventh World Health Assembly: Resolutions and Decisions Plenary Meetings Verbatim Records Committees Minutes and Reports Annexes*. Geneva, No.87. (Retrieved from www.who.int)

resistance of the World Health Assembly against the smallpox campaigns, a resolution to eradicate smallpox was unanimously approved and proposed by the USSR delegate in 1959.[175]

However, progress towards eradication was slow. It was not until 1967, with a commitment to intensify smallpox eradication efforts, that the program was finally taken seriously by WHO and its member countries.

Before this, the WHO office in Geneva lacked adequate information on smallpox eradication progress in its regions. Preoccupied with the Malaria eradication program, smallpox was grossly neglected. The majority of smallpox cases occurred in Asia and Africa, and eradication was still a challenging goal for many countries. It was considered difficult to achieve the eradication goal by many countries in ten years period with a smaller budget, smaller number of health staff appointed at ground level to implement it, and lack of administrative and supervisory structure on storage of vaccine, the technique of vaccination, measurement of success rates absence of documenting and reporting systems on program progress, and consultants for planning and execution of the program and insufficient of supplies of vaccine, heat-stable freeze-dried, transport, refrigerators and other vaccine equipment's. The program needed US$ 40 million to vaccinate twice the then estimated population in endemic areas.[176]

Consequently, at the nineteenth World Health Assembly in 1966, more emphasis was given to coordination among countries and the collaboration of international agencies for the program.

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[175] World Health Organization. (1959). *Twelfth World Health Assembly: Resolutions and Decisions Plenary Meetings Verbatim Records Committees Minutes and Reports Annexes*, Geneva, No. 88. (Retrieved from www.who.int)

[176] Fenner, F., Henderson, D.A., Arita, I., Jezek, Z., & Ladnyi, I. D. (1988). *Smallpox and its Eradication*. Geneva: World Health Organization.

"Noting that particular emphasis has been placed on the need for co- ordination of individual countries' smallpox eradication programmes, 1. DECIDES that the participation of the Organization in the smallpox eradication programme should be financed from the regular budget of the Organization; 2. URGES countries which plan to strengthen or initiate smallpox eradication programmes to take the necessary steps to begin the work as soon as possible; 3. REQUESTS Member States and multilateral and bilateral agencies to provide adequate material support for the realization of the programme" pg. 8[177]

USSR sustained the focus of the Health Assembly on the smallpox eradication goal. However, the program lacked complete international cooperation for the global goal of eradication.

"The smallpox eradication programme will not achieve its objective in the foreseeable future unless it is given a very much greater measure of support than it has received in the past from the governments of the endemic countries, from the smallpox -free countries, and from the international agencies" pg. 174[178]

It was the commitment of the USA in 1965 to support regional smallpox eradication programmes in endemic countries of Africa. It provided a much-needed boost to the eradication efforts worldwide. However, this move of the Health Assembly was taken with disbelief, considering the failure of eradication efforts. Strong opposition came from delegates because of the past unsuccessful eradication experiences campaigns and the failing malaria eradication program at that time launched a decade ago. Despite these oppositions, the resolution was able to get passed for intensifying the smallpox eradication program in 1966 with a $2.4 million per year budget under particular account for smallpox eradication. Additional funds for the program were taken from international donor agencies and the national budget. Dr Donald A Henderson from the US Centres for Disease Control was appointed as the director of Intensified smallpox campaign. His experience proved advantageous for the intensified efforts of the eradication program.

[177] World Health Organization. (1956). *Nineteenth World Health Assembly*: *Part I Resolutions and Decisions Annexes*, Geneva, No. 151. (Retrieved from www.who.int)
[178] World Health Organization. (1965). *Smallpox Eradication Programme: Report by the Director-General, Eighteenth World Health Assembly, Part I Resolutions and Decisions Annexes*, Geneva, No.143. (Retrieved from www.who.int)

Along with mass vaccination campaigns, he introduced Surveillance and outbreak containment as innovative strategies developed at CDC. The new program strategies were effective, and progress was achieved with initial success coming from 20 West and Central African countries, reporting its last case in 1970, followed by Western Hemisphere in 1971. By 1973 except for Ethiopia, all the countries of Africa were smallpox free. The eradication remained a continued challenge in India, Bangladesh, Ethiopia, Nepal and Pakistan. The last case of smallpox in the world was found in Somalia on October 26, 1977. The Global Commission for the Certification of Smallpox Eradication declared no circulating smallpox virus in 1979. The World Health Assembly in May 1980 declared and celebrated the victory of the first eradicated disease on planet earth after a long history of failures received with other disease eradication efforts.[179]

The legacy of the Smallpox eradication program made possible the global use of vaccines to achieve the objective of eradication of a disease. It taught the value of international collaboration to achieve victory for a common public health goal. The program demonstrated the effectiveness of strategies of mass vaccination and outbreak control and established the relevance of robust surveillance for measuring the program's continued progress and identifying its gaps. The program's success resulted from a truly universal effort never undertaken before in any previous eradication or other health programmes. It provided the training ground for gaining experience in implementing immunization or eradication programs on the ground across the globe.[180]

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[179] Henderson, D.A. (2011). The Eradication of Smallpox – An Overview of the Past, Present, and Future. *Vaccine*, 29S D7-D9; Fenner, F., Henderson, D.A., Arita, I., Jezek, Z., & Ladnyi, I. D. (1988). *Smallpox and its Eradication*. Geneva: World Health Organization; Stepan, N.L. (2011). *Eradication: Ridding the World of Diseases Forever?*. New York: Cornell University Press.

[180] Stepan, N.L. (2011). *Eradication: Ridding the World of Diseases Forever?*. New York: Cornell University Press; Henderson, D.A. (2011). The Eradication of Smallpox – An Overview of the Past, Present, and Future. *Vaccine*, 29S D7-D9; Fenner, F., Henderson, D.A., Arita, I., Jezek, Z., & Ladnyi, I. D. (1988). *Smallpox and its Eradication*. Geneva: World Health Organization.

It restores the hope that it was possible to set a global immunization objective, seek collaborative organizational efforts and achieve it systematically. Under Smallpox eradication, health workers could reach the remotest villages in developing countries, ensuring maximum vaccine coverage in a day in almost all areas with local support. This regenerates the enthusiasm that it was possible to make the scientific benefits of vaccines accessible to all under a worldwide goal. Before the smallpox eradication launch in 1967, vaccines were not usually accessible to developing countries, and no national programs vaccinated the entire population. Vaccines were commonly used in industrialized countries, whereas only 15 per cent of developing countries' children received any vaccines.[181]

In the 1980s, smallpox eradication also showed that eradication is possible with a universal standard approach and strategies, with a sufficient budget and uninterrupted supply of vaccines and other equipment. The oral polio vaccine was included in the list of vaccine-preventable diseases for its worldwide distribution. Although the decision on its global eradication took more than a decade after smallpox eradication. But the story of polio eradication is built on essential lessons learned from the legacy of smallpox eradication

3.6 Global Momentum for Equity in Immunization

An era of equity in vaccine coverage began with the development of the Salk polio vaccine. After the announcement of the first polio vaccine in America 1955 in April, it was declared that no American children would be left out of polio immunization due to the inability to pay as the government would purchase all the polio vaccine for all its children.

[181] Stepan, N.L. (2011). *Eradication: Ridding the World of Diseases Forever?.* New York: Cornell University Press; Henderson, D.A. (2011). The Eradication of Smallpox – An Overview of the Past, Present, and Future. *Vaccine*, 29S D7-D9; Fenner, F., Henderson, D.A., Arita, I., Jezek, Z., & Ladnyi, I. D. (1988). *Smallpox and its Eradication*. Geneva: World Health Organization

"This was the day that vaccines became both a personal good and a social good" The era of equity in vaccine coverage had begun" pg. 8 [182]

On 17th May 1955, a polio vaccine proposal to provide free vaccination to lower-income persons of 1 to 19 years of age was supported unanimously in the US Congress and passed by then Chairman Lister Hill of the Senate Labor Committee –

> "Senator H Alexander Smith (R-NJ) introduced a bill carrying out a proposal made by Mrs. Hobby and endorsed by President Dwight D. Eisenhower that the federal government put up 28 million dollars to make sure no child goes without vaccines for lack of money."[183]

With this announcement, global momentum for equity in vaccination programs started.

Globally since the 1950s, the post-World War II period was an era of mass disease campaigns focusing on single diseases. Starting with campaigns against tuberculosis, yaws, leprosy and trachoma were launched. The 1960s saw a large-scale global campaign to eradicate malaria, which failed to eradicate malarial mosquitos and earned a bad name internationally because of its military-style disease campaigns. The period of 1970s saw another large-scale global campaign to eradicate smallpox. Eradication of smallpox was achieved in 1980, and it was considered a significant milestone in the history of eradication initiatives.[184]

As the earlier decades saw campaigns with single disease focus on diseases. By the end of the 1970s and early 1980s, the idea of eradicating the disease was not taken up with great optimism by public health professionals.[185]

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[182] Foege, W.H. (2018). *The Task Force for Child Survival Secrets of Successful Coalitions*. Baltimore: Johns Hopkins University Press.

[183]Latest Deadline in the State Ann Arbor, Michigan. (1955, May 18). *The Michigan Daily*, LXV(160).

[184] Stepan, N.L. (2011). *Eradication: Ridding the World of Diseases Forever?* New York: Cornell University Press.

[185] Stepan, N.L. (2011). *Eradication: Ridding the World of Diseases Forever?* New York: Cornell University Press.

It was a period of a new international economic order. The rising inequalities in the world and improving the health condition in developing countries have become the primary focus of international discussion. More emphasis was given to equity in health, and it became the central theme of the decade.

This period gave a boost to the immunization program in developing countries. A decade-long experience eradicating smallpox paved the way for the resolution of EPI. The smallpox campaign built the necessary administrative and technical techniques, recruited and trained staff and built surveillance systems and other necessary infrastructure to carry vaccines to any part of the world. Many vaccines were already available as a cheap and effective tool to prevent childhood diseases and are extensively used in the industrialized world but not accessible to developing countries. It was easy to use the ground-level system and infrastructure built by smallpox in development to make the vaccine a possible dream for all the children worldwide.[186] Following the legacy of the smallpox eradication programme, resolution for EPI as the next logical big step for global expansion of its role in its countries was taken at Health Assembly.

In 1973 Dr Halfdan Mahler of Denmark became WHO director-general. International momentum for vaccine-preventable immunization programs to promote equity in health was set with the launch of EPI in 1974 against a range of vaccine-preventable diseases, including polio. Building on the experience of smallpox eradication, the World Health Assembly decided to establish an integrated national vaccination program in developing countries called "Expanded Program on Immunization" (EPI) was launched in 1974 to make vaccines accessible to all world's children against childhood diseases. The goal of EPI was to make

[186] Henderson, D.A. (2011). The Eradication of Smallpox – An Overview of the Past, Present, and Future. *Vaccine*, 29S D7-D9.

available and accessible the benefits of vaccine-preventable childhood diseases to the world. Voluntary funds for Health Promotion under a special account were made for donations to the program. Assembly asked its member states to develop and expand their immunization and surveillance programmes for some childhood diseases.[187]

"Noting that in extensive regions of the world immunization is available for only a small proportion of children in the susceptible age- groups." pg. 28[188]

"RECOMMENDS that Member States develop or maintain immunization and surveillance programmes against some or all of the following diseases: diphtheria, pertussis, tetanus, measles, poliomyelitis, tuberculosis, smallpox, and others, where applicable, according to the epidemiological situation in their respective countries" pg. 28[189]

The WHA also asked requested its Director-General to intensify organization activities for expansion and development of immunization programmes in developing countries and assist its member states, seek possibilities of getting international support for funding, supply of vaccines and other equipment, and build local competence for production of vaccines and to increase the supply of quality vaccine at low cost.[190]

The WHO selected Physician and former CDC member Dr Rafe Henderson as head of the EPI program with experience in smallpox eradication in Africa. With this began a new era in which vaccines, as simple, cost-effective tools provided under essential health services, could prevent death and disability each year among children. However, a lot needs to be done before the vaccines can become accessible to children in developing countries under EPI. After its launch, a decade and a half were spent by WHO on promoting EPI for its funding.

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[187] World Health Organization. (1974). *Twenty-Seventh World Health Assembly*: *Part I Resolutions and Decisions Annexes*, Geneva, No. 217. (Retrieved from www.who.int)
[188] World Health Organization. (1974). *Twenty-Seventh World Health Assembly*: *Part I Resolutions and Decisions Annexes*, Geneva, No. 217. (Retrieved from www.who.int)
[189] World Health Organization. (1974). *Twenty-Seventh World Health Assembly*: *Part I Resolutions and Decisions Annexes*, Geneva, No. 217. (Retrieved from www.who.int)
[190] World Health Organization. (1974). *Twenty-Seventh World Health Assembly*: *Part I Resolutions and Decisions Annexes*, Geneva, No. 217. (Retrieved from www.who.int)

Mahler passionately believed that ensuring equity in health provision of primary health services accessible to all people of the world is the first necessity. He was against any short disease campaigns and the building of extensive, expensive curative services to provide health services to people, especially in developing countries.

Mahler's dream was[191] to call a conference jointly sponsored by WHO and UNICEF in 1978 at Alma-Ata in the Soviet republic of Kazakhstan in Central Asia. The conference gave a further boost to equity in immunization services goals. Delegates of 134 governments and 67 UN organizations discussed primary health care (PHC) and accepted the goal of "Health for All " by 2000. Primary health care is an approach which provides universal health care services along with an environment for maintaining healthy living conditions. [192]

As an approach, it calls for the first development of a continuum of comprehensive primary health services (promotive, preventive, curative and rehabilitative care) based on people's needs. Building-integrated health system at the community level and then moving on to addressing the environmental, social and economic factors which impact health under the PHC approach included the goals of providing immunization and high standards of sanitation and living conditions.[193]

Along with the goal of the Alma Atta conference, EPI was based on the principle of comprehensive primary health care and gradually established routine immunization services integrated with other primary health services in WHO member states.

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[191] Mahler, H. (1981). Health 2000: The meaning of "Health for all by the year 2000". *World Health Forum*, 2(I) 9-22.

[192] World Health Organization. (1978). *Primary Health Care: Report of the International Conference on Primary Health Care, Alma-Ata, USSR, September 6–12.* Geneva. (Retrieved from www.who.int)

[193] World Health Organization. (1978). *Primary Health Care: Report of the International Conference on Primary Health Care, Alma-Ata, USSR, September 6–12.* Geneva. (Retrieved from www.who.int)

However, the 1980s was a paradigm shift in the history of public health. The equity model of primary health care promoted at Alma Atta was considered unrealistic. It led to the retreat of the primary health care (PHS) approach. The momentum of *selectivity* in the delivery of health care services started with selective primary health care in 1979 to promote Health for All goal. Two central arguments for the shift from primary health care to selective primary health care were that the primary health care agenda was too broad, idealistic, lacked feasibility, required a limited time period, and lacked resources to achieve the goals of PHC.[194]

The Selective Primary Health Care (SPHC) approach promoted a model of low-cost interventions against the comprehensive primary health care approach. The terms 'cost-effective' and 'package of services' became popular in public health interventions derived from the selective approach. Cost-effectiveness meant that health interventions required low cost but achieved high returns and required less financial and human resources. Package of services meant delivering health services based on prioritization of diseases estimated on mortality and morbidity patterns.[195]

The selective primary health care (SPHC) approach started the momentum of selectivity in public health initiatives, particularly in child care and child survival program. In December 1982, James Grant, the then United Nations Children Fund (UNICEF) executive director, launched an initiative called' child survival revolution' in its annual 'State of World's Children' report, later renamed child development. The campaign goal was universal childhood immunization by the 1990s. The campaign motive was to reverse the conventional wisdom that

[194] Walsh, J.A., and Warren, K.S. (1979). Selective PHC- An interim strategy for disease control in developing countries. *The New England Journal of Medicine,* 30(18), 967-974; Kenneth, N. (1988). Selective PHC: the counter-revolution. *Social Science and Medicine,* 26(9), 903-906; Cueto, M.(2004). The origins of Primary Health Care and Selective Primary Health Care. *American Journal of Public Health*, 94(11).
[195] Walsh, J.A., and Warren, K.S. (1979). Selective PHC- An interim strategy for disease control in developing countries. *The New England Journal of Medicine,* 30(18), 967-974.

rates of infant and young child mortality should be seen as the instrument of development rather than measurements of a country's development. The campaign called for a direct attack on infant and child mortality indicators. Thus, UNICEF proposed overcoming common early childhood infectious diseases using simple, low-cost medical technologies and vertical programs. With this intention UNICEF selective package program GOBI was launched, later known as GOBI-FFF. (Growth Monitoring, Oral Rehydration, Breast Feeding and Immunization [from six vaccine-preventable childhood killers: tuberculosis, diphtheria, whooping cough, tetanus, polio and measles], female education, family education and food supplementation).[196] Child immunization was promoted as one of the most cost-effective interventions for ensuring global equity in access to vaccines worldwide under the package of services promoted by the World Bank in 1993 in its investment in health reports.[197]

The goal of Health for All remained the same ensuring equity in health as decided in 1978, only the approach to delivering it became more selective. This developed tensions between directors of the two largest global health organizations, Jim Grant, head of UNICEF, and Halfdan Mahler, head of the World Health Organization.

The approach to selecting priorities was diametrically opposite to developing comprehensive primary health care through collective action. In his address to the Thirty-Sixth World Health Assembly in 1983, after discussing the monitoring strategy and new managerial framework to put into practice the strategy for health for all goals by 2000 in every WHO member country. Mahler strike at the fragmented action in international health against the

[196] United Nations Children's Fund (UNICEF). (nd). The 1980s: Campaign for child survival. (Retrieved from www.unicef.org); Foege, W.H. (2018). *The Task Force for Child Survival Secrets of Successful Coalitions*. Baltimore: Johns Hopkins University Press.

[197] World Bank. (1993). *World Development Report 1993: Investing in Health*. New York: Oxford University Press. (Retrieved from www.who.int)

singleness of purpose decided by WHO adopted by the collective decision by its member countries under the Health for All goal. Calling the selection approach "Red Herrings," he pointed out that such initiatives are top-down and agenda-driven and divert attention from the health of all goals. He pointed out that such initiatives are against countries' sovereignty to decide their national health affairs and become self-reliant. Selecting isolated elements of the primary health care approach overlooks the other health aspects. It is against the systematic efforts required to build a health infrastructure based on the values of primary health care.[198]

"I am referring to such initiatives as the selection by people outside the developing countries of a few isolated elements of primary health care for implementation in these countries; or the parachuting of foreign agents into these countries to immunize them from above; or the concentration on only one aspect of diarrhoeal disease control without thought for the others. Initiatives such as these are red herrings that can only divert us from the track that will lead us to our goal. They belong to the distant past of international meddling with national health affairs that I mentioned at the beginning of this address.

Such meddling failed then and it will fail now. Indeed, it was partly in reaction to the ultimate ineffectiveness of such action in relation to its costs that the very concept of primary health care was developed. Without building up health infrastructures based on primary health care valuable energy will only be wasted, and you will be deflected from your path. I have no doubts whatsoever about the good intentions of these would-be benefactors, and this makes it all the more difficult to reject their overtures. But I am afraid that that is what we have to do - and more, we must try to channel their energies along agreed lines of action. So, I humbly submit once more that our best protection is to remember the lessons of health history and adhere to our collective policies." pg. 5 [199]

It was an indirect critical comment by Mahler towards Jim Grant of UNICEF's use of a selection of priorities under its GOBI project to achieve equity in health. However, Mahler also pointed toward a more significant problem of lack of cooperation among the other international organization for achieving the Health for All goal. He was commenting on the international interventions by agencies which are against the collective health policy agreed upon by countries

[198] World Health Organization. (1983). *Address by Dr H. Mahler Director-General of the World Health Organization in Presenting His Report for 1982 to the Thirty-Sixth World Health Assembly*, Geneva, WHA36/DIV/4. (Retrieved from www.who.int)

[199] World Health Organization. (1983). *Address by Dr H. Mahler Director-General of the World Health Organization in Presenting His Report for 1982 to the Thirty-Sixth World Health Assembly*, Geneva, WHA36/DIV/4. (Retrieved from www.who.int)

After World War II, large international organizations such as WHO and UNICEF were formed. However, many bilateral and multilateral agencies emerged formed by the countries to aid the developing countries in health, agriculture, and development. The global health community got many actors working with different agendas. Early 1980 at the international level, competition not only increased among the global health community. However, at the country level, the influence of many global health agencies including multilateral and bilateral organizations was growing, working simultaneously to advance their organizational agenda and national pride.[200]

More significantly, the primary source of differences between global health agencies was the approach taken for implementing health interventions – vertical versus horizontal. The selection of priorities in developing countries for public health intervention was against the more cohesive and comprehensive approach of developing an integrated primary health care model.

Immunization was one of the essential goals of primary health care models. However, immunization programs alone as a vertical program were more appealing to few individual global actors as they produced tangible and measurable results. Many multilateral and bilateral organizations were also enthusiastic about providing aid for the immunization programs in countries. However, the problem between other international agencies and Mahler was that under the primary health care model, immunization was to be provided as an integrated service with other general services and not as a vertical program.[201]

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[200] Foege, W.H. (2018). *The Task Force for Child Survival Secrets of Successful Coalitions*. Baltimore: Johns Hopkins University Press.
[201] Foege, W.H. (2018). *The Task Force for Child Survival Secrets of Successful Coalitions*. Baltimore: Johns Hopkins University Press.

Between WHO and UNICEF, the two prominent organizations' apparent tussle was because of the selective, more vertical approach taken to achieve equity in health UNICEF. Despite critical comment by Mahler on meaning fewer interventions taken by international agencies, Jim Grant did not change his new strategy adapted to prioritize selected health services for children's needs over the primary health care approach in countries.

At the thirty-seventh World Health Assembly (WHA) in 1984, Mahler, again taking up the issue of lack of international cooperation on joint health policy goals, stated that over the past one-year international cooperation was strengthened among various agencies agreeing to work in line with universally agreed goal of Health for All.

"One voice rejoices that over the past year cooperation between WHO and a host of other parties concerned with health has been closer and friendlier than ever. Cooperation has been particularly intensive with UNICEF. It has also been productive with UNDP and the World Bank, with other multilateral agencies, many bilateral development agencies and a number of dedicated individuals, institutions and foundations in political, economic and scientific spheres. We have learned together to be pragmatic without ever losing sight of our goals, rather than being dogmatic and endangering the continued universal acceptance of these goals." pg.5[202]

On the other hand, there was skepticism among many international actors on achieving global cooperation for achieving universally defined goals. Mahler disagreed with the opinion that achieving cooperation among international agencies was difficult. He discussed the first Bellagio conference at the thirty-seventh WHA and how it successfully bridged the gaps between international agencies, bringing them together to protect the health of the world's children.

" But another voice is less exultant; it points to the limitations of this kind of cooperation. Just to give you one example, I should like to let you know of an ambitious initiative that was launched in recent months by a number of eminent individuals. They were instrumental in bringing together most of the major development agencies to consider undertaking jointly a highly intensive effort to protect the health of the world's children. We learned once more that it is essential to focus on specific issues in countries rather than attempting worldwide coordination of operational activities. This experience only serves to strengthen my personal conviction that the best form of

[202] World Health Organization. (1984). *Address by Dr H. Mahler Director-General of the World Health Organization in Presenting His Report for 1982 & 1983 to the Thirty-Seventh World Health Assembly*, Geneva, WHA37/DIV/4. (Retrieved from www.who.int)

cooperation between developed and developing countries is the kind of enlightened support I have been emphasizing so much in recent years. That, I repeat, implies pursuing an agreed national course of action that is consistent with collective policy, in which the government, the people aid all external partners have clearly defined roles, and in which each external partner retains its identity and visibility in fulfilling its role within the national strategy. WHO's overriding role in that is to help countries to ensure that external support is provided in that way." pg. 5[203]

Although Mahler was determined to promote a comprehensive primary health care model to establish a more balanced approach to delivering health services in developing countries. However, he also felt emasculated that the global health environment was not conducive to accepting the comprehensive primary health care approach.[204]

3.7 Accelerating the EPI

At the thirty-fifth World Health Assembly, the Director-General discussed a five-point action programme for accelerating the EPI in countries. The five-point action called to –

"Promote the Expanded Programme on Immunization (EPI) within the context of primary health care, invest adequate human resources in EPI; invest adequate financial resources in EPI; ensure that programmes are continuously evaluated and adapted so as to achieve high immunization coverage and maximum reduction in target-disease deaths and cases; pursue research efforts as part of programme operations." pg.26[205]

Based on the discussion of the EPI report recommendation, the world health assembly took a significant resolution in which it recognized the goal of EPI – "to provide immunization for all children of the world by 1990" as an essential element of WHO's the strategy to achieve health for all by the year 2000.[206]

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[203] World Health Organization. (1984). *Address by Dr H. Mahler Director-General of the World Health Organization in Presenting His Report for 1982 & 1983 to the Thirty-Seventh World Health Assembly,* Geneva, WHA37/DIV/4. (Retrieved from www.who.int)
[204] Foege, W.H. (2018). *The Task Force for Child Survival Secrets of Successful Coalitions*. Baltimore: Johns Hopkins University Press.
[205] World Health Organization. (1982). *Thirty -Fifth World Health Assembly: Resolutions and Decisions Annexes*. Geneva, WHA35/1982/REC/1. (Retrieved from www.who.int)
[206] World Health Organization. (1982). *Thirty -Fifth World Health Assembly: Resolutions and Decisions Annexes*. Geneva, WHA35/1982/REC/1. (Retrieved from www.who.int)

The health assembly warned members that to achieve the 1990 goal, EPI progress must be accelerated and requested member states to accelerate EPI activities based on the five-point programme. The director-general of WHO was asked to increase the effectiveness of the national immunization programmes by intensifying collaboration with the Member States.[207]

The health assembly resolution to accelerate EPI in 1982 gave great impetus to immunize all children of developing countries under the primary health care approach principles. After two years, in 1984, on March 13th, a conference was called at Rockefeller Foundation Centre in Bellagio, Italy - "Protecting the World's Children: Vaccines and Immunization within Primary Health Care".

Headed by Robert McNamara, thirty-four people attended the conference with a common concern to protect the world's children against childhood diseases. Under the leadership of Henderson as director of EPI, the program capacity was significantly got boosted in WHO member countries. He recruited dedicated staff with experience from the smallpox program to build the necessary basic infrastructure for the programme delivery.[208]

At the Bellagio conference, RH Henderson, the EPI program director, began the conference by presenting the grave situation of childhood mortality and morbidity in developing countries, the progress of EPI in the last eight years and the remaining challenges for its improvement.[209]

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[207] World Health Organization. (1982). *Thirty -Fifth World Health Assembly: Resolutions and Decisions Annexes*. Geneva, WHA35/1982/REC/1. (Retrieved from www.who.int)

[208] Foege, W.H. (2018). *The Task Force for Child Survival Secrets of Successful Coalitions*. Baltimore: Johns Hopkins University Press.

[209] Henderson, R.H. (1984). Vaccine Preventable Diseases of Children the problem. *In: Protecting the World's Children: Vaccines and Immunization within Primary Health Case, A Bellagio Conference*, The Rockefeller Foundation; Henderson, R.H. (1984). Providing Immunization: The state of the Art. *In: Protecting the World's Children: Vaccines and Immunization within Primary Health Case, A Bellagio Conference*, The Rockefeller Foundation.

Presenting the statistics, Henderson told the conference participants that in 1983 around 3 million children died and 5 million per year (10 per minute) suffered the disability caused by five vaccine-preventable diseases.[210]

Despite the availability of vaccines and their cost-effectiveness providing immunization as a primary health service remained a challenge in developing countries after 1977, although WHO members countries committed to developing immunization services. However, significant variation in expansion and effectiveness among countries significantly impacts vaccine coverage. In developing countries, political will is needed to finance adequately and adequately recruit trained staff for the programme. Management capacity is severely constrained to absorb the donor resources such as vaccines and other equipment and deliver an effective program. The immunization program requires strengthening a surveillance system for reporting disease incidence.

Further, there are not many health services delivery posts for availing services to communities. The early year of life of infant's more critical, and survival is challenging exposed to infections and malnutrition. Thus, immunization should be an integrated primary care service addressing infections and malnutrition problems.[211]

Supporting programs in all countries in developing and expanding immunization services EPI program progressed significantly in the past eight years. Immunization schedules were made, vaccine procurement was standardized, and its delivery was simplified. Two

[210] Henderson, R.H. (1984). Vaccine-Preventable Diseases of Children the problem. *In: Protecting the World's Children: Vaccines and Immunization within Primary Health Case, A Bellagio Conference*, The Rockefeller Foundation.
[211] Henderson, R.H. (1984). Vaccine-Preventable Diseases of Children the problem. *In: Protecting the World's Children: Vaccines and Immunization within Primary Health Case, A Bellagio Conference*, The Rockefeller Foundation; Henderson, R.H. (1984). Providing Immunization: The state of the Art. *In: Protecting the World's Children: Vaccines and Immunization within Primary Health Case, A Bellagio Conference*, The Rockefeller Foundation.

methods were developed to immunize children even in remote villages with no fixed health posts - outreach clinics and mobile teams. Production capacity of vaccines and strengthening of vaccine quality were progressing in many large developing countries. However, improvement in syringes sterilization techniques is lacking in many countries. To keep the vaccines potent in hot and humid climates of tropical countries, cold chain technology was improved, and vaccine vails monitor for checking vaccine potency from production to injection was introduced. Around 95 per cent of the world's children quickly get the potent vaccine through an "unbroken cold chain", but its full use remained weak. Training programs and systems to deliver it were developed and established. Training courses were sponsored by WHO and UNICEF worldwide, providing necessary skills to thousands of health staff. Research and development for simplifying and improving the program were emphasized. Critical information systems were established and improved. Routine reporting systems for measuring the incidence of diseases and immunization coverage and evaluation mechanism were defined but not fully applied. The establishment of health services with community involvement is still lacking in many developing countries resulting in immunization and high dropout rates between the first and third dose of DPT.[212]

Vaccines were less readily available to children in developing countries than in earlier eras. After eight years of the EPI, the vaccine coverage improved significantly from less than 5 per cent to around 30 per cent of children under one year of age who received a third dose of DPT vaccine, 24 per cent received the third dose of polio and 14 per cent only measles immunization. However, the vaccine coverage remained minor, and children were still dying.

[212] Henderson, R.H. (1984). Vaccine Preventable Diseases of Children the problem. *In: Protecting the World's Children: Vaccines and Immunization within Primary Health Case, A Bellagio Conference*, The Rockefeller Foundation; Henderson, R.H. (1984). Providing Immunization: The state of the Art. *In: Protecting the World's Children: Vaccines and Immunization within Primary Health Case, A Bellagio Conference*, The Rockefeller Foundation.

The EPI program needed acceleration of the program to achieve its 1990 objective. The reassuring fact Henderson made in his presentation was that the total cost to establish an immunization programme for infants in developing countries required only US$ 0.20-0.60 per capita. To fully immunize a child in developing countries, the cost ranges from US$ 5.00-15.00. Approximately 80 per cent of this cost consists of salaries of health staff coming from the budgets of developing countries. The estimation of the cost-effectiveness of immunization delivery as part of primary health services was strong enough to appeal to donors to contribute to the financial gaps in the EPI program.[213]

Henderson, in his presentations, emphasized the possibility of accelerating EPI as the basic methods and infrastructure to immunize children were available, WHO standards and protocols were developed, and methods of evaluation of the program were defined. The blueprint for conducting immunization programs in developing countries was already in place. The need was to fund it adequately and accelerate the efforts in developing countries. He also emphasized establishing immunization services integrated into primary health care to facilitate more excellent management and utilization of immunization. However, also increase accessibility to other essential health services by the community.

Other papers at the conference discussed how the biotechnology revolution could provide vaccines for other diseases, methods and techniques through which immunization services could establish primary health care, mainly using merchandising and social marketing techniques. The success of the Kolda-Kaya-Kolokani immunization program in Africa using two doses of inactivated polio vaccine strategy. The conference's outcome was not only a plan

[213] Henderson, R.H. (1984). Vaccine Preventable Diseases of Children the problem. *In: Protecting the World's Children: Vaccines and Immunization within Primary Health Case, A Bellagio Conference*, The Rockefeller Foundation; Henderson, R.H. (1984). Providing Immunization: The state of the Art. *In: Protecting the World's Children: Vaccines and Immunization within Primary Health Case, A Bellagio Conference*, The Rockefeller Foundation.

to immunize all children of the world under EPI by 1990. However, promote other effective methods such as oral rehydration, child spacing and family planning to reduce morbidity and mortality in developing countries among children.[214]

After eighteen months after the first meeting in 1985, Bellagio II was organized at Cartagena, Colombia. The second Bellagio conference was more successful as, by this time, interests in immunization had grown, resulting in massive participation in the conference. The first conference focused on current challenges in the immunization program, how to address them, and estimates of required resources.[215]

The second Bellagio was more dominated by the confidence and enthusiasm of participants towards the immunization program, particularly achieving 80 per cent of immunization coverage within the next five years. Discussions were majorly done on the progress achieved so far and examples of success stories on achieving the immunization goals.[216]

3.9 Task force on Child Survival

At the Bellagio Conference, Jim Grant, director of UNICEF, proposed establishing an ad hoc task force for child survival to accelerate EPI to achieve the 1990 goal of protecting the world's children.

[214] Protecting the World's Children: Vaccines and Immunization within Primary Health Case, A Bellagio Conference. (1984). *The Rockefeller Foundation*.
[215] Foege, W.H. (2018). Bellagio II in Cartagena, October 1985. *In: The Task Force for Child Survival Secrets of Successful Coalitions* (Chapter 8). Baltimore: Johns Hopkins University Press.
[216] Foege, W.H. (2018). Bellagio II in Cartagena, October 1985. *In: The Task Force for Child Survival Secrets of Successful Coalitions* (Chapter 8). Baltimore: Johns Hopkins University Press.

WF Foege, former CDC director, presented a paper on the to accelerate immunization activities and the role of the task force to facilitate it. [217]

Emphasizing *Can We and Will We*? Foege presented his ideas on the possibilities of immunization acceleration in developing countries and proposed a three-point program on how to achieve it – 1) accelerate the expansion of immunization coverage to those developing countries where children contribute disproportionately to the vaccine-preventable disease mortality; 2) simultaneously provide increased support for immunization services to all other developing countries to assure they are not constrained by the lack of vaccine, supplies, equipment, or technical assistance; and 3) intensify research and development to improve current immunization and delivery system technology. These actions should all be designed and made available in such a way as to contribute to the development of national health infrastructure.[218]

All the conference participants accepted the proposal on the task force after discussion and modification.[219]

The taskforce, in the initial stages of its formation, consists of only three former CDC professionals supported by the Rockefeller Foundation, UNICEF, the WHO, the United Nations Development Programme and the World Bank. The task force as a not-for-profit agency's purpose was to function as a temporary agency outside of its founding international

[217] Foege, W.H. (1984). Protecting the World's Children: Strategies for Attaining the Goal. *In: Protecting the World's Children: Vaccines and Immunization within Primary Health Case, A Bellagio Conference*, The Rockefeller Foundation.

[218] Foege, W.H. (1984). Protecting the World's Children: Strategies for Attaining the Goal. *In: Protecting the World's Children: Vaccines and Immunization within Primary Health Case, A Bellagio Conference*, The Rockefeller Foundation, p. 83.

[219] Protecting the World's Children: Vaccines and Immunization within Primary Health Case, A Bellagio Conference. (1984). *The Rockefeller Foundation*.

agencies to facilitate their global commitment to reaching 80 per cent of children with vaccines by 1990.[220]

The need to facilitate immunization work by an outside agency arises from the ongoing conflicts of interests between the agencies holding them back from coherently working for an effective immunization program in developing countries resulting in delays. Recognizing their ongoing ego conflicts and the significance of 1990 global commitment, the agencies agreed to form a *small, informal, anonymous*, private group to help them work together.[221]

WF Foege was chosen by Jim Grant and Halfdan Mahler to head the task force on child survival in a private informal meeting held with him before the Bellagio conference to discuss the plan for forming a task force.

"A strange thing happened as plans were devised for the initial meeting of donors to accelerate the global immunization campaign, to be held at the Rockefeller Center in Bellagio, Italy. Jim Grant and Halfdan Mahler met privately with me and for a short time. I felt like a therapist. They told me that they both had such big egos that they sometimes had trouble getting along. They said, "No wonder our agencies have trouble working with each other." But they both knew that for the good of child health they had to figure out a way to make immunization programs work." pg.24[222]

Foege agreed to head the task force and give a presentation at Bellagio on its structure and function. The task force aimed to facilitate child health and global immunization goals.[223]

"If I agreed to lead such a task force, Grant and Mahler said, we need to understand in advance that it could never compete with the agencies, it must keep an appropriately low profile, and it should never use the word *coordinate* because neither agency wanted to be coordinated nor would any other agency that agreed to be part of the coalition. The world settled on was *facilitate*." pg.24&25[224]

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[220] Foege, W.H. (2018). *The Task Force for Child Survival Secrets of Successful Coalitions*. Baltimore: Johns Hopkins University Press.
[221] Foege, W.H. (2018). *The Task Force for Child Survival Secrets of Successful Coalitions*. Baltimore: Johns Hopkins University Press.
[222] Foege, W.H. (2018). How Productive Coalitions Begin. *In: The Task Force for Child Survival Secrets of Successful Coalitions* (Chapter 4). Baltimore: Johns Hopkins University Press.
[223] Foege, W.H. (2018). *The Task Force for Child Survival Secrets of Successful Coalitions*. Baltimore: Johns Hopkins University Press.

[224] Foege, W.H. (2018). How Productive Coalitions Begin. *In: The Task Force for Child Survival Secrets of Successful Coalitions* (Chapter 4). Baltimore: Johns Hopkins University Press.

Within a short period, the task force's work gained enormous popularity. Championing the agenda of global health equity, it made the world's five powerful international agencies work in a coalition to achieve a shared objective - the Rockefeller Foundation, UNICEF, the WHO and the United Nations Development Programme, and the World Bank.[225]

In six years, the immunization coverage increased from about 25 per cent of children, reaching 80 per cent of world children with at least one vaccine by Jim Grant, executive director of UNICEF, at the 1990 Summit for Children on September 30.[226]

Although formed for a short duration, the significance and popularity of the task force for child survival grew enormously to facilitate other global health projects. It not only produced a successful model for the coalition. However, it also could raise considerable resources for organizations. It successfully supported three programs Merck & Co.'s Mectizan Donation Program for onchocerciasis donated to prevent river blindness more than 1 billion following the coalition model Task Force.[227]

3.10 Rotary Dream to Eliminate Polio

Rotary International (RI) club's first meeting started on 23rd February 1905 in Chicago with a vision of Paul Harris (a lawyer professional who settled in Chicago) to form an organization for local professionals to collaborate and exchange and discuss ideas. Soon the organization's work expanded to humanitarian services. Rotary clubs expanded from city to

[225] Foege, W.H. (2018). *The Task Force for Child Survival Secrets of Successful Coalitions*. Baltimore: Johns Hopkins University Press.
[226] Foege, W.H. (2018). *The Task Force for Child Survival Secrets of Successful Coalitions*. Baltimore: Johns Hopkins University Press.
[227] Foege, W.H. (2018). *The Task Force for Child Survival Secrets of Successful Coalitions*. Baltimore: Johns Hopkins University Press.

city, focusing on projects serving the local community's needs. The work began by addressing local community-level challenges at national and later expanded internationally, focusing on addressing world needs.[228]

The legacy of Rotary International in polio immunization started with its "crippled children's work". In just twelve years of formation, the rotary work on ensuring rehabilitation of children with disabilities was majorly focused as an ideal service project giving a sense of purpose to rotary members. It ensures its outstanding achievement. The rotary concern and enthusiasm for children with disabilities paved the path for a later global leadership role in global polio eradication.[229]

This service project to rehabilitate children experiencing disabilities gave Rotarians a sense of purpose to raise funds and help children and their families affected by polio disability and disabilities caused by other reasons. It was also considered an opportunity to make a long-lasting difference in their efforts. The project gathered a sense of personal commitment and local level involvement of more significant Rotarians members from business and other professionals at the ground level.[230]

In 1917 rotary board established an endowment fund to support collective work addressing world problems. Rotary's concern for children with disabilities and their rehabilitation grew over time, making a more significant impact through global cooperation. In each state and district, every Rotary club was a member of International, state and national crippled children societies, funding and supporting their society's work. However, this

[228] Cook, S.G. (2013). *Rotary and the Gift of a Polio-Free World, Making the Promise Rotary*. Rotary International Publication, Vol1.
[229] Cook, S.G. (2013). *Rotary and the Gift of a Polio-Free World, Making the Promise Rotary*. Rotary International Publication, Vol1.
[230] Cook, S.G. (2013). *Rotary and the Gift of a Polio-Free World, Making the Promise Rotary*. Rotary International Publication, Vol1.

cooperative for disabled children's work grew so much in scale that it became a problem for the rotary to maintain its identity and autonomy as an organization. As each rotary club was only focused on rehabilitating children's work by collaborating with other organizations, Rotarians feared the organization could get consumed by it. So, in 1923 at RI convention adopted a resolution 23-24, giving autonomy to each rotary club to choose the service work and voluntary participation in the rotary broader purposes such as disabled children's work. Thus, as voluntary leaders in disabled children's work, rotary clubs systematically continued expanding this work, some clubs focusing on serving the local needs of their community, others aligning their purpose with the general aim of rotary to help "crippled children" work.[231]

From 1977 to 1978, Jack Davis, as President of Rotary, decided on the theme "Serve to Unite Mankind" for his tenure to address the world's needs by directing rotary efforts and expanding rotary work to a more significant international level. Consistent with this purpose, Davis wished to focus one year on the needs of children; 1979 was taken as the year United Nations International Year of the Child.[232]

Focusing its attention on addressing world needs and needs of world children board of rotary decided to agree to focus on worldwide immunization of children and adults from 1978-1980. On the 75th Anniversary of the organization in 1980, the rotary planned to do something on a grand scale apt for the occasion. A separate anniversary fund was formed to support larger club projects. On the 75th anniversary, incoming President Clem Renouf formed the program Health, Hunger and Humanity or 3H with the presidential theme "reach out".[233]

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[231] Cook, S.G. (2013). *Rotary and the Gift of a Polio-Free World, Making the Promise Rotary*. Rotary International Publication, Vol1.
[232] Cook, S.G. (2013). *Rotary and the Gift of a Polio-Free World, Making the Promise Rotary*. Rotary International Publication, Vol1.
[233] Cook, S.G. (2013). *Rotary and the Gift of a Polio-Free World, Making the Promise Rotary*. Rotary International Publication, Vol1.

Consistent with the rotary objective to focus on international service programs, the 3H program was centrally funded under the guidance of a new 3H committee. The 3H committee wanted to use the program to make a mark in international projects, which the rotary has not done before. As the program formally took form, each rotary club focusing on improving health, addressing hunger and working on social development projects was included under the 3H program centrally funded. For the first year, the 3H theme was the needs of children recognizing the international year of the child. Each rotary club committed to raising funds for 75the anniversary and 3H rotary projects of their own and other clubs.[234]

The projects under 3H program were large projects for any club or district to fund. The RI board initially decided to fund a single large project under the 3H program and later expand it to other projects. As a rotary, many clubs from the start focused on the immunization of children, and there was much support for the immunization program within the rotary board. The 3H committee decided to initiate a particular project on immunization.[235]

President Renouf, inspired by 1980 smallpox eradication, got a suggestion from Dr John Sever (chief of infectious diseases branch, Institute of Neurological Diseases, US National Institute of Health) on which disease to focus for a single immunization program. Dr John Sever was a vaccine researcher and closely associated with Albert Sabin. After consulting with Sabin, Dr Sever suggested eradicating Poliomyelitis.[236]

[234] Cook, S.G. (2013). *Rotary and the Gift of a Polio-Free World, Making the Promise Rotary*. Rotary International Publication, Vol1.
[235] Cook, S.G. (2013). *Rotary and the Gift of a Polio-Free World, Making the Promise Rotary*. Rotary International Publication, Vol1.
[236] Cook, S.G. (2013). *Rotary and the Gift of a Polio-Free World, Making the Promise Rotary*. Rotary International Publication, Vol1.

In 1979 rotary board set the goal of "the eradication of poliomyelitis and alleviation of its consequences" (page 46) [237]

Eradication of poliomyelitis became the primary 3H goal, and in 1980 the council on legislation added "working with other agencies…….to help eliminate polio through immunization" pg.46[238] and passed the resolution.

The 3H committee is focusing on the goal of eliminating polio and plans to immunize a single country using the funds of the 75th-anniversary fund and working in collaboration with WHO EPI director Rafe Henderson starting selecting a country for its first immunization demonstration project. Henderson cautions rotary repeatedly against any donor-assisted short-term immunization campaign as they will not bring any significant impact to the needs of communities. However, the rotary moved on with its ambitious immunization project under 3H and selected the Philippines as its first demonstration site at the request of President Dr Sabino Santos of the country. The Philippines lacked funds for the recently started national immunization program and thus did not include the polio vaccine.[239]

The rotary immunization project in the Philippines started with the delivery of more than seven thousand tetanus toxoid doses for free to pregnant women donated from Cannaught laboratories in Ontario, Canada. Getting administrative and management experience from this in 1979 launched a five-year polio immunization project with $ 760,000 funds from 75th-anniversary funding. The project was a collaborative effort of WHO, the government of the Philippines and rotary. The government of the Philippines deliver the six million polio vaccines

[237] Cook, S.G. (2013). *Rotary and the Gift of a Polio-Free World, Making the Promise Rotary*. Rotary International Publication, Vol1.
[238] Cook, S.G. (2013). *Rotary and the Gift of a Polio-Free World, Making the Promise Rotary*. Rotary International Publication, Vol1.
[239] Cook, S.G. (2013). *Rotary and the Gift of a Polio-Free World, Making the Promise Rotary*. Rotary International Publication, Vol1.

provided by rotary under the EPI. Rotarians of the country promoted immunization mobilizing the parents to vaccinate their children.[240]

Working towards the future hundredth anniversary in 2005, the RI president Clem Renouf hoped to seek new goals beyond the current goals of rotary. Aligning with this intention and the objective of addressing the world's needs in 1981, president McCaffrey of California created a new horizon committee. The committee was formed to propose future goals to the board of directors for RI to pursue. The proposal to immunize every child with the polio vaccine and eradicate polio by 2005 was among the committee's several proposals from rotary members and clubs. The committee chose this goal because immunizing with the polio vaccine was already on the priority list of the 3H program, and many Rotary clubs were already involved with immunization work at local levels. Philippine's project was set as a model for 3H polio immunization projects. The success was enormous in just six months of starting the project in January 1980. By July 1980, the polio vaccine could cover 90 per cent of children's targeted age group. The number of polio cases declined to 68 per cent in the first two years of the 3H project. After the Philippines rotary expanded its polio immunization efforts to other countries of Haiti and Bolivia, providing them grants and vaccines for immunization under EPI and other countries such as Morocco, Sierra Leone, and the Gambia were also asking for rotary help. After the rotary council on legislation endorsed the goal of working with other agencies to immunize and eliminate polio disease in 1980, the 3H committee has suggested setting a date in the same year. The new horizon committee facilitated the 3H committee work and set 2005, the hundredth anniversary of RI, as the target date to eliminate polio in every country. For the rotary committee, the goal of eliminating polio to protect the world's children did not

[240] Cook, S.G. (2013). *Rotary and the Gift of a Polio-Free World, Making the Promise Rotary*. Rotary International Publication, Vol1.

seem difficult but only required sustained and expanded efforts towards achieving the goal. However, neither the RI board nor its committee had any idea of the funds required to achieve this goal. The new horizon committee believed that the availability of fixed grants per year would ensure polio vaccine coverage to children of developing countries.[241]

Spontaneous cost estimates for the polio vaccine were made roughly $20 million or $25million, or about $ 1 million per year to move forward with the work to achieve the polio elimination goal. Without any funding plan, the new horizon committee proposal was accepted by RI directors and encouraged every club and district to work on immunization of children against communicable diseases in collaboration with the EPI of WHO and national and local authorities. The 3H committee prepared a plan to achieve the worldwide goal involving all clubs and districts. In 1982, in February, RI adopted the goal to provide polio immunization integrated with EPI to protect the world's children with the target deadline of the 100th anniversary of RI in 2005.[242]

In late 1982 Dr Carlos Canseco from Monterrey, Mexico, was chosen as the next president of RI (1984-85). Canseco was close to Albert Sabin and worked with him in Mexico on national polio immunization days and testing of improved measles vaccine in 1982 before he was appointed president of RI. Till now, polio in rotary funding countries has been delivered under WHO EPI. However, Canseco coming the understating of efficiency of the mass immunization program, told the new 3H committee that routine immunization in ongoing EPI is only wasting the vaccine RI provides to countries. Canseco pursued the RI members to adopt the strategy of intensive mass immunization campaign giving children polio vaccines every

[241] Cook, S.G. (2013). *Rotary and the Gift of a Polio-Free World, Making the Promise Rotary*. Rotary International Publication, Vol1.
[242] Cook, S.G. (2013). *Rotary and the Gift of a Polio-Free World, Making the Promise Rotary*. Rotary International Publication, Vol1.

day. This strategy was supposed to be effective in eliminating poliovirus, particularly in low immunization coverage countries.[243]

The rotary members were skeptical of the Canseco proposal and lacked the technical expertise to propose such plans on national immunization days (NIDs) to countries. The WHO and its director Henderson were not supportive of the mass immunization model as it does not support the general health system of the country. However, Canseco instated intensive polio vaccine campaigns and was against the EPI model. Rotary needed the technical answers related to the mass immunization strategy for polio elimination for promotion in its funding countries.[244]

On 1983, March 14-17 International Symposium on the Control of Poliomyelitis was held in Washington, DC[245]. RI sent two rotary members, John Sever and Carlos Canseco were sent by RI to attend the symposium to get technical answers to its mass immunization campaign proposal.[246]

The conference was attended by ministers of health, immunologists from several countries, and Salk and Sabin, the polio vaccine developer. At the symposium, several papers were presented to discuss the incidence and prevalence of worldwide polio, its epidemiological aspects, experiences of many countries in control of polio, the efficacy of the Sabin oral polio vaccine and its immune response. A discussion was also done on lameness surveys and

[243] Pigman, H.A. (2005). *Conquering Polio A brief History of PolioPlus, Rotary's Role in a Global Program to Eradicate the World's Greatest Crippling* Disease. Rotary International Publication; Cook, S.G. (2013). *Rotary and the Gift of a Polio-Free World, Making the Promise Rotary*. Rotary International Publication, Vol1.
[244] Pigman, H.A. (2005). *Conquering Polio A brief History of PolioPlus, Rotary's Role in a Global Program to Eradicate the World's Greatest Crippling* Disease. Rotary International Publication; Cook, S.G. (2013). *Rotary and the Gift of a Polio-Free World, Making the Promise Rotary*. Rotary International Publication, Vol1.
[245] International Symposium on Poliomyelitis Control. (1984). *Review of Infectious Diseases,* 6, S302-S307.
[246] Pigman, H.A. (2005). *Conquering Polio A brief History of PolioPlus, Rotary's Role in a Global Program to Eradicate the World's Greatest Crippling* Disease. Rotary International Publication; Cook, S.G. (2013). *Rotary and the Gift of a Polio-Free World, Making the Promise Rotary*. Rotary International Publication, Vol1.

strategies for eliminating polio in different parts of the world using oral polio vaccine and mass immunization strategy. The most important discussion was on the possibility of eliminating polio. However, the symposium reached no agreement on using a mass immunization strategy in developing countries. Non-availability of basic infrastructure in many countries hindered the adoption of a mass immunization strategy for polio control.[247]

As accepted, Rotary members did not receive any answers to the question from experts at the symposium on the effectiveness of the mass immunization strategy. Later, the rotary did not get any support from WHO director-general Dr Halfdan Mahler at the 1984 World Health Assembly using mass immunization campaigns for polio vaccination. Thus, Rotary decided to promote both mass polio immunization strategy and integrated EPI model of WHO for polio immunization in its funding country. It was left for the health ministers to take any strategy as per their feasibility. However, president Carlos Canseco pursued a vision to use the mass immunization strategy in rotary funding countries and later got WHO endorsement for this work. By 1984 following the conference, the international rotary set up a consultative committee to review the potential for global efforts to eradicate poliomyelitis. In 1985, based on the committee report recommendation, rotary international launched polio plus programme to eradicate poliomyelitis by 2005 and pledged to invest US$ 120 million. This was considered the first and largest internationally coordinated private-sector support for a public health initiative.[248]

However, the goal of polio elimination set for the rotary's hundredth anniversary looked too daunting to the organization, and a long-term commitment could not be achieved in just 20

[247] International Symposium on Poliomyelitis Control. (1984). *Review of Infectious Diseases*, 6, S302-S307.
[248] International Symposium on Poliomyelitis Control. (1984). *Review of Infectious Diseases*, 6, S302-S307; Pigman, H.A. (2005). *Conquering Polio A brief History of PolioPlus, Rotary's Role in a Global Program to Eradicate the World's Greatest Crippling* Disease. Rotary International Publication; Cook, S.G. (2013). *Rotary and the Gift of a Polio-Free World, Making the Promise Rotary*. Rotary International Publication, Vol1.

years left for its anniversary. Rotary as an organization was unclear on an action plan for achieving the objective. Many directors and trustees gradually stood apart from the Polio 2005 goal of the 3H program. The Polio 2005 goal under 3H became a separate program. So later on, advise of public relations consulting firm, the name *eliminate* changed to *plus*. The plus reflected the inclusion of other communicable diseases apart from polio which Rotarians could provide to countries if good funds are available. Thus in 1985, the Polio 2005 program became PolioPlus -*To immunize the world's children*.[249]

Rotary remained committed to immunizing children worldwide against polio, not using the term eliminate. Until this period, only Rotary International and Dr Ciro A. de Quadro of Pan America Health Organization (PAHO), WHO region for Americas, were only supporters of mass immunization strategy and polio elimination goals worldwide.[250]

3.11 Adapting Global Polio Eradication Model from Experiences of Latin American Countries

Polio immunization under the EPI was just an immunization program to control the polio prevalence in the countries and other vaccine-preventable diseases. The global commitment to eradicate polio gradually set the stage for global efforts. Before the launch of EPI, more emphasis was given to international polio surveillance in the WHO region member countries, and a technical guide for a system of poliomyelitis surveillance was launched in 1971. This made international polio surveillance and reporting of outbreak mandatory for all

[249] Pigman, H.A. (2005). *Conquering Polio A brief History of PolioPlus, Rotary's Role in a Global Program to Eradicate the World's Greatest Crippling* Disease. Rotary International Publication; Cook, S.G. (2013). *Rotary and the Gift of a Polio-Free World, Making the Promise Rotary*. Rotary International Publication, Vol1.
[250] Pigman, H.A. (2005). *Conquering Polio A brief History of PolioPlus, Rotary's Role in a Global Program to Eradicate the World's Greatest Crippling* Disease. Rotary International Publication; Cook, S.G. (2013). *Rotary and the Gift of a Polio-Free World, Making the Promise Rotary*. Rotary International Publication, Vol1.

member countries.[251] Until 1985 eradication of poliomyelitis disease was not considered feasible for eradication. In 1983 International Symposium on Poliomyelitis Control was organized by Pan American Health Organization (PAHO) and WHO at Washington, DC. The issue to eradicate versus control of polio among the polio experts was discussed and debated attending the conference. It was considered that it was not feasible to eradicate polio in 20th century. There was great apprehension among the member states to take the polio eradication goal at that time due to technical problems in detecting the presence of wild poliovirus and lack of political will.[252]

With continuous use of oral polio vaccine in the United States of America the struggles with polio disease came to an end in the year of 1979 with elimination of the polio virus. But much of the research and developments on global polio eradication initiative universal strategies was done outside of United States in the under-developed areas of American region.

Hungary on December 1959 launched the first nationwide mass vaccination using the Sabin polio vaccine strains. Czechoslovakia followed using the live oral polio vaccine in nationwide mass immunization campaigns started in 1960 became the first country in the world to eliminate feared disease of polio. Eastern European countries laid the foundation of polio eradication during the Cold War period.[253]

In PAHO WHO region Cuba following the success model of Czech launched the polio immunization campaign in 1962 successfully eliminated the polio within a year. Cuba polio immunization campaign became the most successful modelled program in the history of polio

[251] World Health Organization. (1972). Poliomyelitis in 1971. *Weekly Epidemiological Record,* 41, 31:293-99. (Retrieved from www.who.int)
[252] International Symposium on Poliomyelitis Control. (1984). *Review of Infectious Diseases,* 6, S302-S307.
[253] Vargha, D. (2018). *Polio Across the Iron Curtain Hungary's Cold War With an Epidemic*. Cambridge University Press.

eradication for other Latin American countries and the world. Cuba was the first country in developing region of PAHO to massively use the mass immunization strategy as National Immunization days poliomyelitis twice a year using OPV to eliminate poliovirus. House to house strategy was a model used extensively in successfully polio campaigns in Cuba.[254]

The Pan American Health Organization (PAHO) motivated with the success in United States decided to expand the program in the region. By 1985 it was PAHO American region of WHO which made the first regional commitment to eradicate poliomyelitis from the region by the year of 1990. The PAHO mission was to change the program's course from just achieving control to eliminating the polio virus from the American region. PAHO commitment to eradication changed the already existing perspective among polio experts that polio cannot be eradicated.[255] Later in Latin America many countries adopted and implemented Cuban policy model with some variations to eliminate the poliovirus.[256]

PAHO region framed and released the guidelines on procedure to conduct national immunization days (NID), polio surveillance and reporting.[257] This laid the foundation for eradication of polio disease from other developing countries.

The blueprint of the global polio strategies to implement across the WHO regions came from the experience of highly successful polio eradication model implemented in countries of Latin America, the WHO PAHO region (Pan American Health Organization). However, much of the evidence on safety and efficacy of oral polio vaccine came from large field trails and

[254] International Symposium on Poliomyelitis Control. (1984). *Review of Infectious Diseases,* 6, S302-S307; Cruz, R. R. (1984). Cuba: Mass Polio Vaccination Program, 1962-1982. *Reviews of Infectious Diseases*,6(2)
[255] World Health Organization. (1988). Expanded programme on immunization: Global advisory group. *Weekly Epidemiological Record*, 63, 3, 9-13. (Retrieved from www.who.int)
[256] Risi Jr, B.J. (1984). The Control of Poliomyelitis in Brazil. *Review of Infectious Diseases* 6,(2).
[257]World Health Organization. (1988). Expanded programme on immunization: Technical advisory group (TAG) on eradication of poliomyelitis in the Americas. *Weekly Epidemiological Record*, 63, 4, 17-20. (Retrieved from www.who.int)

practicability of polio mass vaccination campaigns from Russia and Eastern European countries.

After the success of the poliomyelitis program in the Latin America's under-developed areas, the world was ready with the vaccine and strategies to implement the world-wide poliomyelitis eradication war against the poliomyelitis disease particularly in the countries with socio economic conditions similar to that of Latin America. The Latin American polio eradication program answered much of the concerns of implementing polio vaccination program in tropical endemic regions with varied climatic and socio-economic conditions.

At the WHO international meeting in November,1987 praising the PAHO's regional effort on eradicating poliomyelitis WHO endorsed the goal of global poliomyelitis eradication.[258]

PAHO achieved the goal to eradicate polio in 1991 and become the first region in the world as polio free in 1994. The PAHO region success laid the foundation for eradication of polio disease from other developing countries.[259] Latin American polio elimination model became strong evidence to rally support for GPEI from donors and members countries.

3.12 Eradicate Poliomyelitis from Spaceship Earth by the Year 2000

By the late of twentieth century the modern epidemiological definition of the Poliomyelitis, its causative agent, its routes of transmission, and vaccination to prevent the disease were known to the world. Largescale mass immunization program using oral polio

[258] World Health Organization. (1988). Expanded programme on immunization: Global advisory group. *Weekly Epidemiological Record*, 63, 3, 9-13. (Retrieved from www.who.int)
[259]World Health Organization. (1985). Expanded programme on immunization: Goal for 1990 - eradication of Poliomyelitis in the Americas, *Weekly Epidemiological Record*, 60, 51/52, 394-95. (Retrieved from www.who.int); Thomas, D. M. & Robbins, F.C. (1997). *Polio*. New York: University of Rochester Press.

vaccine were already successful many industrialized countries and developing country. Smallpox was declared eradicated and confidence for selecting another disease for eradication was high among international health community.

The successful elimination of polio virus from Latin American regions in 1991 built the hope of future eradication of polio in developing countries tropical regions. The Latin American model gave two major strategies for elimination of polio virus national immunization days and house to house campaigns. These strategies to eliminate poliomyelitis in developing countries were well tested in the under-developed regions of Latin America with similarities to the contextual environment of developing countries.

Disappearance of polio virus from American region inspired the world community and laid the foundation for eradicating polio from rest of the world. It was the PAHO regional success which boosted the eradication goal and shaped the global polio eradication initiative (GPEI).

The goal of polio eradication was first discussed in March of 1988 at the Bellagio III in Talloires, France. At the conference, Henderson Rafe the WHO EPI director announced to the participants that in developing countries half of children are successfully administered three doses of DPT and polio vaccines and substantial progress is made in reducing infant and childhood mortality compared to previous earlier twenty-five years.[260]

The Bellagio III is significant in the history of global health because the conference became the foundation for setting the worldwide goal of polio eradication. Members of ministers of health from some of the largest countries of the world gathered at the conference

[260] Foege, W.H. (2018). Bellagio III in Cartagena, October 1985. *In: The Task Force for Child Survival Secrets of Successful Coalitions* (Chapter 10). Baltimore: Johns Hopkins University Press.

not only discussed the scientific basis of polio eradication. However, also, were convinced by Herb Pigman former general secretary of Rotary International to support the rotary vision to eradicate polio within their countries. The outcome of Bellagio III was the Declaration of Talloires. The declaration included seven goals presented to countries and health organizations as a plea to achieve them by the year 2000. The goal of *Global Eradication of Polio* was given strong priority and was put first on the list of seven goals.[261]

Two months after the Declaration of Tallories the goal of polio eradication was adopted by the WHO and member countries ministers of health. It was in the year of 1988, the forty first World Health Assembly passed a resolution to eradicate poliomyelitis by the year 2000 and certification by 2005.

"Aware that poliomyelitis is the target disease most amenable to global eradication, and that regional eradication goals by or before the year 2000 have already been set in the Regions of the Americas, Europe and the Western Pacific;

Recognizing that the global eradication of poliomyelitis by the year 2000, a goal cited in the Declaration of Talloires, represents both a fitting challenge to be undertaken now, on the Organization's fortieth anniversary, and an appropriate gift, together with the eradication of smallpox, from the twentieth to the twenty-first century. "pg 1[262]

1. DECLARES the commitment of WHO to the global eradication of poliomyelitis by the year 2000; pg 2[263]

The year 1988 was also significant as the WHO director-general Halfdan Mahler announced his retirement from the WHO. Mahler in his last address before retirement to the forty-first WHA strongly supported the goal of polio eradication and expressed his confidence in achieving the goal of eradication of polio disease by 2000. This was in contradiction to the primary health care approach which he strongly advocated throughout his career as head of

[261] Foege, W.H. (2018). Bellagio III in Cartagena, October 1985. *In: The Task Force for Child Survival Secrets of Successful Coalitions* (Chapter 10). Baltimore: Johns Hopkins University Press.
[262] World Health Organization. (1988). *Forty-First World Health Assembly, Global eradication of poliomyelitis by the year 2000*, Geneva, WHA41.28. .(Retrieved from www.who.int)
[263] World Health Organization. (1988). *Forty-First World Health Assembly, Global eradication of poliomyelitis by the year 2000*, Geneva, WHA41.28. .(Retrieved from www.who.int)

WHO. Speaking on WHO four decades of achievements in his final address to WHA he supported the goal to eradicate poliomyelitis from spaceship earth by 2000.

"Who among the cynics and sceptics would have thought that when you the World Health Assembly, said we should be immunizing all the world's children by 1990 against the major killer childhood diseases - who among them believed we could reach that target? I am not saying we are there altogether, but at least we have moved from less than 5% 10 years ago to more than 50% fully-immunized children in the world today, saving much more than a million children from dying from these diseases, or becoming crippled by poliomyelitis each year. The Diarrhoeal Disease Programme too is saving more than one million children from dying from diarrhoeal diseases every year. Indeed, I would like to challenge you on the basis of these results - what about having the guts to suggest that we should eradicate poliomyelitis from spaceship earth by the year 2000! I think we should. I think it is do-able. And therefore there is no excuse for not trying and trying very hard to do it." pg 1 & 2[264]

The eradication goal was promoted as a gift from twentieth to the twenty-first century.[265]. Polio vaccine was already included in the EPI immunization schedule and implemented in all WHO member countries.

Achievement of polio eradication required not only plenty of human financial resources investment. However, also, the political will of countries to make the global polio eradication goal possible. The efforts put in to achieve the goal of polio eradication were required enable strengthening of Expanded Programme on Immunization and other health programmes especially concerning the needs of women and children. Members countries achieving 70 per cent of three doses of polio vaccine were encouraged to operationalize a plan of action for eliminating of wild poliovirus which also strengthen their national immunization programmes. Members countries not achieving 70 per cent coverage rate were asked to accelerate efforts to achieve the required polio vaccine coverage as soon as possible.[266]

[264]World Health Organization. (1988). *Address by Dr H. Mahler Director-General, World Health Organization on the occasion of the celebration of the fortieth anniversary of WHO and tenth anniversary of the Declaration of Alma-Ata during the forty-first World Hearst Assembly*, Geneva. (Retrieved from www.who.int)
[265] World Health Organization. (1988). *Forty-First World Health Assembly, Global eradication of poliomyelitis by the year 2000*, Geneva, WHA41.28. .(Retrieved from www.who.int)
[266] World Health Organization. (1988). *Forty-First World Health Assembly, Global eradication of poliomyelitis by the year 2000*, Geneva, WHA41.28. .(Retrieved from www.who.int)

The success of strategies for the eradication of poliovirus in under-developed and developing regions was presented and promoted to the world and to the polio endemic countries by the WHO PAHO region. The 1988 WHA asked all the member countries to strengthen surveillance capacities and polio immunization efforts. The WHO was requested to strengthen technical capacities for adequately providing the necessary support in planning, training and supervision to countries for national immunization programs. Also, to conduct an evaluation of immunization programs in countries with less than 70 per cent coverage of three doses of polio for making the required improvements.[267]

A plan of action to accelerate efforts for polio immunization was adopted to achieve the eradication goal by 2000.[268] At the Forty Second World Health Assembly in 1989 the plan of action was promoted by WHO and to achieve polio eradication goal 80 percent of polio immunization coverage was set as a target for WHO member countries.[269]

After the 1988 global commitment to eradicate polio WHO accelerated the efforts in its regional countries. The global commitment to eradicate polio by 2000 was a collaborated effort where for implementing national polio immunization program extensive technical and funding support from all the international polio partner organizations was given to all the WHO member countries at regional level. Developed countries and other countries reporting the absence of transmission of poliovirus had major responsibilities to extend their support to other polio endemic countries and share their technical expertise and resources.

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[267] World Health Organization. (1988). *Forty-First World Health Assembly, Global eradication of poliomyelitis by the year 2000*, Geneva, WHA41.28. .(Retrieved from www.who.int)
[268] World Health Organization. (1988). *Global poliomyelitis eradication by the year 2000: plan of action*. Geneva. (Retrieved from www.who.int)
[269] World Health Organization. (1989). *Forty-Second World Health Assembly*: Resolutions and Decisions, Annexes. Geneva. (Retrieved from www.who.int)

However, the richer polio-free countries had major long-term financial benefits for supporting and accelerating the goal of polio eradication in endemic regions.[270]

3.13 The Global Choice of Vaccine & Strategies Polio Eradication Campaigns

The availability of vaccine as a simple low-cost solution to polio problem resulted in the elimination of poliovirus in the 1960s and 1970s from high-income countries. Thus, the disappearance of poliovirus from developed countries inspired the global health community and this laid the foundation for eradicating of polio from the rest of the world. The OPV became the vaccine of choice for the eradication of polio globally by the World Health Organization (WHO) because of its long-term efficacy and its lower cost. The social benefits of eradicating polio for children across the world became the core of promoting the polio eradication program in countries.[271]

Unlike the Salk's vaccine, Sabin's live-attenuated polio vaccine was considered essential for eradication of polio because of its superior scientific capacity to eliminate the poliovirus. The live polio vaccine was capable of breaking the chain of the transmission of polio infection. It provided the necessary alimentary tract immunity which prevented re-infection and the spread of polio infection offering an additional immunity to close contacts of vaccinated person. Furthermore, the low cost of the Sabin vaccine and the ease of orally giving the OPV to humans by any medically unskilled individual were added advantages for its use in mass immunization campaigns.

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[270] World Health Organization. (1995). Expanded programme on immunization: Progress towards poliomyelitis eradication, *Weekly Epidemiological Record*, 14, 97-104. (Retrieved from www.who.int)

[271] World Health Organization. (1997). *Polio: The beginning of the End*. Geneva: World Health Organization. (Retrieved from www.who.int)

The year of 1992 became very significant for achieving the goal of polio eradication by 2000. As less than eight years remained to achieve the global target worldwide significant changes were made to accelerate the efforts in polio endemic countries. Thus, a revised plan of action was promoted by EPI Global Advisory Group from October 1992 to endemic countries. The revised plan of action ensured the necessary environments for achieving the global eradication target on time. Primary emphasis was given to ensuring political commitment at all levels of the global community, adequate financial resources, adequate OPV vaccine doses and establishment of effective polio surveillance system.[272]

The EPI model for achieving the polio eradication initiative appeared insufficient to achieve the polio eradication to the global community. By the year of 1992 it was recognized that polio eradication in many of the countries is not possible to achieve through the routine immunization under EPI.

> A high immunization coverage delivered through primary health care systems is the foundation upon which the eradication initiative is built. The plan of action also recognizes that poliomyelitis eradication cannot be achieved in most countries through routine immunization programmes alone. Three supplementary immunization strategies are specified: national immunization days, immunization in response to outbreaks, and "mopping up". In these strategies, all children less than 5 years of age in a defined area, regardless of prior immunization status, are immunized over a period of a few days pg 225[273]

Thus, a vertical program model for polio eradication was promoted by WHO under the revised global plan of action. The plan supported the use of supplementary immunization strategies (SIAs) in countries to be adopted for the eradication of polio. This laid the foundation to develop a separate system for immunizing children against poliovirus in endemic countries and conducting national immunization days (NIDs).

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[272] World Health Organization. (1993). Expanded programme on immunization (EPI): Poliomyelitis in 1992, *Weekly Epidemiological Record*, No. 31, 225-230. (Retrieved from www.who.int)

[273] World Health Organization. (1993). Expanded programme on immunization (EPI): Poliomyelitis in 1992, *Weekly Epidemiological Record*, No. 31, 225-230. (Retrieved from www.who.int)

The global polio program was not just an immunization program to control polio disease. But an eradication program to eliminate the poliovirus. Thus, its strategies were designed to reach the last child with oral polio vaccine even in the remotest and difficult areas ensuring maximum coverage of the children with oral polio vaccine. Mass Immunization Campaigns using OPV was considered a feasible strategy to eradicate poliovirus worldwide by 2000.

Four-point strategy was promoted in 1995 World Health Assembly for achieving the eradication goal.[274] Two essential strategies for achieving maximum immunization coverage were - Routine Immunization and Supplementary Immunization days. The four-point strategy widely promoted across the WHO regions. It comprises high routine immunization coverage with OPV; supplementary immunization in the form of national immunization days or mass campaigns; effective surveillance; and in the final stages, when very few or no cases are occurring, door to-door immunization campaigns ("mopping up") in areas where the virus persists.

3.14 Global Actors and Funding of the GPEI

It was a global commitment to eradicate polio globally by the year 2000. Global Polio Eradication Initiate was launched as a most significant international collaboration to eradicate the Poliomyelitis disease. The Global Polio Eradication Initiative (GPEI) was a creative collaboration of four key organizations World Health Organization, Rotary International, US Centre for Disease Control and Prevention (CDC), and United Nations International Children Emergency Fund (UNICEF). World Health Organization provided the leadership for the global effort to eradicate polio in developing countries, and perform operation and monitoring

[274] World Health Organization. (1998). Expanded programme on immunization: Progress towards Poliomyelitis eradication, *Weekly Epidemiological Record* 73(8), 49-53. (Retrieved from www.who.int)

functions. Rotary international as one of the prominent initiators of global polio effort perform role of advocacy, funding, and social mobilisation. United Nations Children's Fund (UNICEF) as key partner performed the role of vaccine procurement, communication, and social mobilization. Centre for Disease Control and Prevention (CDC), funded by US federal government perform the surveillance activity.[275]

Cost of eradication in GPEI is estimated in dollar value involves components such as GPEI funding in country spend on eradication; ongoing costs spend on polio vaccines through the routine immunization system; and in-kind contributions within countries such as time spent by volunteers, health workers, and others on planning and implementation supplementary immunization activities.[276] The Polio Eradication & Endgame Strategic Plan 2013-2018 (PEESP) categories cost in four significant activities - immunization activities, surveillance and response capacity, poliovirus containment and certification, and core functions and infrastructure[277]

Eradication program is long term and requires strong economic justification for motivating the donors to invest. The investment in GPEI was economically justified by health economists and is considered the most cost-effective initiative than any other alternatives.[278] It is estimated that GPEI would generate net benefits of US$ 40-50 billion within the period of 1988-2035, savings from avoiding treatment costs for paralytic polio and rehabilitation.[279] It

[275] World Health Organization. (1997). *Polio: The beginning of the End*. Geneva: World Health Organization. (Retrieved from www.who.int)

[276] Polio Global Eradication Initiative. (nd). *Economic Case for Eradicating Polio*. (Retrieved from www.polioeradication.org)

[277] World Health Organization. (2013). *Polio Eradication &Endgame Strategic Plan 2013-2018*. WHO, France. (Retrieved from www.polioeradication.org)

[278] Polio Global Eradication Initiative (nd). *Economic Case for Eradicating Polio*. (Retrieved from www.polioeradication.org); Tebbens et al. (2011). Economic analysis of the global polio eradication initiative. *Vaccine* 29, 334–343.

[279] Tebbens et al. (2011). Economic analysis of the global polio eradication initiative. Vaccine 29, 334–343.

also produces additional net benefits occurred during polio campaigns such as benefit to routine immunization systems, support to other health programmes, and child mortality reduction associated with improved delivery of Vitamin A doses.[280]

The GPEI is supported by substantial financial investment and pooling of funds from different sources all over the world from donors and contributors. Leading private organizations partners are the Bill and Melinda Gates Foundation, United States Agency for International Development (USAID), G7 countries, European Commission, OECD countries, multilateral organizations, donor countries, other private and non-governmental donors, governments of polio-effected regions/countries through domestic resources, all pledged to fund the GPEI for protecting children of the world against polio virus.[281]

Total contribution of US$ 14,265,79 million was made possible to the Global Polio Eradication Initiative (GPEI) between the period of 1985-2019 by these organization (Polio Global Eradication Initiative 2016**).** India through domestic resources spends a total of US$ 1321.68 million within the same period for eradicating the polio from the country. Other key organizations such as Bill & Melinda Gates Foundation contributed US$ 2864.82 million, rotary international (US $ 1518.70 million), UNICEF (US$ 245.77 million), USA (US $ 2,641.12 million).[282]

Polio Eradication & Endgame Strategic Plan 2013-2018 (PEESP) estimated US$ 5.5 billion for eradicating polio by 2018. However, the deadline for global certification is pushed

[280] Polio Global Eradication Initiative (nd). Economic Case for Eradicating Polio; Tebbens et al. (2011). Economic analysis of the global polio eradication initiative. Vaccine 29, 334–343

[281] Polio Global Eradication Initiative (2016) Contributions and Pledges to the Global Polio Eradication Initiative, 1985-2019

[282] Polio Global Eradication Initiative (2016) *Contributions and Pledges to the Global Polio Eradication Initiative, 1985-2019*. (Retrieved from www.polioeradication.org)

to 2019 thus the estimated US$ 5.5 billion over the period of 2013-2018 by PEESP has been increased by US$ 1.5 billion to US$ 7.0 billion for period of 2013-2019 to carry out GPEI activities.[283] In the year 2015 the GPEI had a total direct expenditure of US$ 1.0 billion.[284] It is estimated that total eradication and post eradication activities will only cost US$ 10-16 billion for over 20 years between the periods of 2013-2033.[285]

3.15 Diffusion of Polio Eradication Goal and Strategies in Developing Countries

Eliminating polio was presented as gift from twentieth century to twenty- first century. It was a humanitarian benefit to reduce human suffering and death from polio in endemic regions of poorest and least developed countries.[286]

The problem of identification of polio as a threatening disease to the success of strategies for eradication of poliovirus in developing regions of polio endemic countries was already presented to the world by the PAHO region. After the success of the Poliomyelitis program in the Latin America under- developed areas, the world was ready with the tool, vaccine and strategies to implement the world-wide poliomyelitis eradication war against the poliomyelitis diseases particularly in the polio endemic countries.

The world health assembly resolution generated the international momentum for eradicating the second disease after small pox success. After the global commitment polio eradication efforts accelerated dramatically from 1988 to 2000. The World Health Organization

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[283] World Health Organization (2016). *Financial Resource Requirements 2013-2019.* (Retrieved from www.polioeradication.org)
[284] Polio Global Eradication Initiative (2015) *Expenditures*. (Retrieved from www.polioeradication.org)
[285] Polio Global Eradication Initiative (nd). *Economic Case for Eradicating Polio*. (Retrieved from www.polioeradication.org)
[286] World Health Organization. (1988). *Forty-First World Health Assembly, Global eradication of poliomyelitis by the year 2000*, Geneva, WHA41.28. .(Retrieved from www.who.int); World Health Organization. (1998). *Report of the Second Meeting of the Global Commission for the Certification of the Eradication of Poliomyelitis*. Geneva. (Retrieved from www.who.int)

played critical role in generating the international momentum for polio eradication and diffusion of polio immunization program in countries in polio endemic countries. Within the span of a decade the goal of polio eradication was adapted from countries to countries in polio endemic regions of WHO. The process of diffusion of global polio eradication policy was first from north to south diffusion and then it was south to south diffusion. Polio endemic developing countries adapted the model of Latin American for planning and implementation of the national immunization program for achieving the polio eradication.

The polio program was not an immunization program but an eradication program to eliminate the poliovirus in each country. Thus, its strategies were designed to reach the last child with oral polio vaccine even in the remotest and difficult areas ensuring maximum coverage of the children with oral polio vaccine. There were four-pronged strategy in the based on the model Latin America promoted in the countries for eradication of the polio.[287]

Four-point strategy was promoted in 1995 World Health Assembly for achieving the eradication goal.[288]

Two important strategies for achieving maximum immunization coverage were – maintaining high Routine Immunization coverage and Supplementary Immunization Campaigns (SIAs) with oral polio vaccine to interrupt the transmission of poliovirus.

Routine immunization was the cornerstone of the polio eradication strategy to reach children with oral polio vaccine. Achieving and maintaining high routine immunization coverage of oral polio vaccine among children under one years of age to reach each and every

[287] World Health Organization. (1997). *Polio: The beginning of the End*. Geneva: World Health Organization. (Retrieved from www.who.int)
[288] World Health Organization. (1995). Expanded programme on immunization: Progress towards poliomyelitis eradication, *Weekly Epidemiological Record*, 14, 97-104. (Retrieved from www.who.int)

child under one year of age was critical strategy of the overall program. Initially WHO established a global target of at least 90 percent immunization coverage for all vaccines used in the Expanded Programme on Immunization, including oral polio vaccine, by the year 2000 but this target was failed to be achieved.[289]

Supplementary Immunization days including national immunization days were the core of the strategy implemented 4-6 weeks apart in the country twice in the country irrespective of pervious immunization. The national immunization days were supplementary immunization campaigns implemented complementary to routine immunization giving additional doses of OPV to immunize every child under five years of age. These supplementary doses of OPV ensure to maintain the immunity among children against the polio virus already immunized and remove the epidemiological opportunities for the polio virus to grow throughout the year.

For achieving the maximum vaccine coverage strong polio surveillance system in every country was the essential to detect areas of circulating poliovirus and investigate every case of paralysis for confirming poliomyelitis. Surveillance system identify all cases of acute flaccid paralysis (AFP cases) in the area. It was the most significant activities of the programme to ensure verification of areas where polio virus transmission was interrupted and areas which require strengthening of immunization efforts. Supporting the surveillance activities in 1990 Global Polio Laboratory Network was formally established to detect presence of wild and vaccine derived polio virus in countries in endemic regions.[290]

The last strategy was mopping-up immunization campaigns in targeted high-risk areas with persistent of poliovirus transmission for stopping the circulation of poliovirus. The mop -

[289] World Health Organization. (1997). *Polio: The beginning of the End*. Geneva: World Health Organization. (Retrieved from www.who.int)
[290] World Health Organization. (1997). *Polio: The beginning of the End*. Geneva: World Health Organization. (Retrieved from www.who.int)

up were door- to door immunization campaigns to be implemented in an area when very few or no cases of polio are occurring. These campaigns mop polio the virus still circulating in high-risk districts for final interruption of chain of polio transmission in the area. The criteria of identifying areas for mop-up activities include occurrence of wild polio virus in the previous three years and areas where access to health care is difficult, overcrowding, high population mobility, poor sanitation, and low routine immunization coverage.[291]

After the interruption of polio virus transmission, the countries were required to maintain absence of wild polio virus transmission for at least three consecutive years to be officially declared polio free. Certification of polio eradication in a WHO Region is considered when all countries in that region demonstrate absence of polio virus transmission along with presence of certification standard surveillance for all cases of acute flaccid paralysis (AFP cases) and on completion of phase one of laboratory containment activities for wild poliovirus.[292]

3.16 Polio Eradication Program in South East Asia Region

The polio vaccination program was an international diffusion of polio from American PAHO region to other countries. It was a global diffusion from north to south. But later on, it was south to south diffusion which started the polio vaccination program in countries including SERO region. Countries after countries adopted the polio eradication goal in South Asia. Regional offices of WHO played a critical role in generating the initial momentum and political will for starting the polio vaccination program in the SEARO member countries.

[291] World Health Organization. (1997). *Polio: The beginning of the End*. Geneva: World Health Organization. (Retrieved from www.who.int)
[292] World Health Organization. (1998). *Report of the Second Meeting of the Global Commission for the Certification of the Eradication of Poliomyelitis*. Geneva. (Retrieved from www.who.int)

Implementation of NIDs in tropical South East Asia Region (SEARO) was significant for the global success of the polio eradication initiative. This was essential for two factors 1) the region comprises of largest population almost 1/5 of the world population 2) The region was one of the major sources of risk of polio virus transmission to other polio free countries.

In the SEARO region alone along with Pakistan over three quarters of polio cases were reported in the year of 1988. Around 60 percent of reported polio cases by 1993 were originated from Indian subcontinent. In the SEARO region of WHO 4184 cases were reported in 1994 which was 67 per cent of the global total. India alone reported 3867 polio cases in 1994. Problem of Polio in Indian subcontinent was given priority in first global polio certification meetings and in later years.[293]

By the year 1994 the worldwide progress achieved toward poliomyelitis eradication indicated that many of the key technical problems in implementing polio immunization campaigns were resolved. The only major impediments that remained were concerns related to availing adequate financial resources to carry out polio eradication activities and political will within the countries to start the national immunization days (NIDs).[294]

The diffusion of polio immunization program in ten SEARO countries began with Maldives other countries adopted the program much later. Between the period of 1994 to 1996 NIDs were implemented in the other nine countries of SEARO. Polio vaccination program started with implementation of National Immunization Days (NIDs) in 1994 in Thailand followed by 1995 in Bangladesh, Bhutan, India, Indonesia, and Sri Lanka and in 1996 in

[293] World Health Organization. (1995). Expanded programme on immunization: Progress towards poliomyelitis eradication, *Weekly Epidemiological Record*, 14, 97-104. (Retrieved from www.who.int); Centers for Disease Control & Prevention (CDC). (1993). *Morbidity and Mortality Weekly Report*, 42(24). (Retrieved from www.cdc.gov)

[294] World Health Organization. (1995). Expanded programme on immunization: Progress towards poliomyelitis eradication, *Weekly Epidemiological Record*, 14, 97-104. (Retrieved from www.who.int)

Democratic People's Republic (DPR) of Korea, Myanmar and Nepal. By the time NIDs were started in other SERO region, Maldives had already achieved the polio-free status.

In the SEARO region polio immunization program implementation was coordinated activity with the purpose to eliminate poliovirus from the entire region. For this purpose, major emphasis was given to synchronized NIDs implementation in the SEARO region in the same week among SEARO countries and with other neighbouring countries. The polio immunization program implementation level policy learning, in the beginning, was north to south. But later much of the learning in implementing the polio program was south-south, learning shared among South Asia countries through cross-national sharing of policy ideas and strategies.

3.17 History of Polio Vaccination in India Prior to Eradication Program

There were several domestic factors at work responsible for diffusion of the polio eradication goal in India at national level. As the world was going through discussion and debate on polio epidemics India was not unaffected with the whole debate. In India the disease was not a major public health problem until 1979 when polio vaccine become part of EPI.

Before this period there were many independent research works going on understanding the polio disease. There were many scientific studies done in India to understand the poliovirus magnitude, its risks factors, efficacy of polio vaccine in reducing mortality and morbidity in the country.[295] Since the first international conference on poliomyelitis in 1948 Indian scientists were regularly communicating their study findings on to understanding of epidemiology of polio to international scientists' community.

[295] John, T.J. (2016). India's Research Contributions Towards Polio Eradication (1965-2015). *Indian Journal of Pediatrics*,53, (1-6).

3.17.1 Magnitude of Polio in India

India adopted Expanded Programme on Immunization (EPI) in 1978. But OPV was not initially introduced in EPI with DPT (diphtheria, pertussis [whooping cough], and tetanus) and BCG (Bacillus Calmette-Guerin) vaccines. In India polio vaccine was introduced in national immunization program from 1979.

Before the introduction of polio vaccine, the wild polio virus infection annual incidence in the country in pre-school children is estimated to 48 per 100 of which 63 per 100 was reported in infancy and 23 per 100 in 4-year-old children.[296] Children from lower socio-economic families were more susceptible to polio. In localities where polio effected children families resides there was high prevalence of other communicable diseases such as typhoid, diarrhoea and measles and presence of environmental factors spreading the diseases. Children infected with polio virus mostly sought treatment from other providers before visiting hospital for treatment. Despite introduction of polio vaccines there was overall low awareness among people about vaccination including other childhood vaccines irrespective of education and economic status.[297]

After the introduction of polio vaccine in national immunization program information on polio disease was very limited. Central Bureau of Health Intelligence (CBHI) was the only source for understanding the magnitude of poliomyelitis in the country. But the hospital-based surveillance information provided by state health authorities to CBHI was limited in reporting the true magnitude of polio in the country. Baseline epidemiological data for planning of polio

[296] John, T.J., Kamath, K.R., Feldman, R.A., & Christopher, S. (1970). Infection and Disease in A Group of South Indian Families. IX. Poliovirus Infection Among Preschool Children. *Indian Journal of Medical Research*, 58,551-5.
[297] Prasad, B.G., Jain, V.C., Kumar, K.A., & Suraiya, M. (1972). Some case studies on social aspects of poliomyelitis, Lucknow. *Indian Journal of Pediatrics*, 39, 397.

actions and measuring the impact of polio vaccine on morbidity and mortality in the country was needed. In the context of no proper surveillance of polio in the country national sample survey was conducted to estimate the incidence and prevalence of polio in the urban and rural areas of the country. These state level surveys used lameness survey methodology enumerated the residual polio paralysis in children aged 5 – 9 years of age.[298]

These baseline sample lameness surveys (for surveillance of polio) were conducted in 1981 and 1982. These surveys covered a period when OPV polio vaccine immunization services in the country were not available. These surveys stated that in India poliomyelitis was an early childhood disease and there was no increase in age as seen in the western developed countries. Polio was largely an early childhood disease mostly infecting below two years of age and few cases were reported in children below one years of age. Reporting of polio cases was predominantly underestimated in the country through CBHI. As the disease was highly prevalent reporting 20-25 cases of paralytic polio (per 100000). Polio incidence was equal in both rural areas and urban areas in states. Paralyzing legs of the children in about 75 to 80 percent of the polio cases and leading to deaths in one-fourth of the polio cases.[299]

Similar findings were reported from state level individual surveys conducted in Southern part of India. Age of onset of paralysis was less than one year of age in children.[300] Male children were more susceptible to diseases compared to female. Mostly children of 2-3 years of age were at higher risk then infants with prevalence of 6.4 per 1000 and 1 per 1000

[298] Basu, R.N. (1981). Magnitude of problem of poliomyelitis in India. *Indian Journal of Pediatrics*,18.
[299] Basu, R.N. (1981). Magnitude of problem of poliomyelitis in India. *Indian Journal of Pediatrics*,18.
[300] Srinivasa, D. K. et al. (1997). Poliomyelitis trends in Pondicherry, South India, 1989-91. *Journal of Epidemiology Community Health*, 51(4), 443–448.

respectively. Polio paralysis was mostly affecting the legs of children (97 percent of children).[301]

The program strategy before the start of Pulse Polio Immunization (PPI) program was focused only to control polio through sustained high levels of immunization coverage of OPV under routine immunization. The OPV was administered to targeted children during monthly immunization sessions along with outreach immunization sessions.

The immunization coverage of OPV increased in second half of 1980s in many states and districts. The coverage level at national level reached close to 75 to 80 percent in 1990-91.[302] With increase in immunization coverage a declining trend of polio was recorded at national, state and district level from 1989 to 1991.[303] The immunization coverage surveys recorded reduced incidence of polio from 28,350 in 1987 to less than 10,000 in 1990 and 5,669 in 1991.[304]

In some states sustained improvement in immunization coverage reached close to universal coverage of OPV.[305] Despite dramatic increase in coverage reported from large number of the states and districts variation in performance of OPV coverage was prevalent within and across states and districts in the country. Many states and districts were close to

[301]Soudarssanane, M. B., Rotti, S.B., Srinivasa, D.K., & Ramalingam, G. (1993). Paralytic Poliomyelitis in Children Under 6 Years in Pondicherry: Community Survey. *Journal of Epidemiology Community Health*, 47(3) 210–214.
[302] Sokhey, J. (1992). Poliomyelitis Surveillance in India, Special Article. *Indian Journal of Pediatrics*, 29.
[303]Srinivasa, D. K. et al. (1997). Poliomyelitis trends in Pondicherry, South India, 1989-91. *Journal of Epidemiology Community Health*, 51(4), 443–448; Sokhey, J. (1992). Poliomyelitis Surveillance in India, Special Article. *Indian Journal of Pediatrics*, 29.
[304] Sokhey, J. (1992). Poliomyelitis Surveillance in India, Special Article. *Indian Journal of Pediatrics*, 29.
[304] Srinivasa, D. K. et al. (1997). Poliomyelitis trends in Pondicherry, South India, 1989-91. *Journal of Epidemiology Community Health*, 51(4), 443–448.
[305] Srinivasa, D. K. et al. (1997). Poliomyelitis trends in Pondicherry, South India, 1989-91. *Journal of Epidemiology Community Health*, 51(4), 443–448.

reaching zero polio case status. But substantial gap in immunization coverage was consistent in low to moderate performing districts.[306]

In the early years of immunization program in India regularity, completeness, and reliability were major problems in immunization surveillance. Many efforts were put in to strengthen the immunization surveillance such as introduction of sentinel surveillance system and collection and monitoring of surveillance data under Universal Immunization Programme (UIP) at district level. Several additional efforts were taken to strengthen the surveillance of polio in the country from 1989. But overall gaps remained along with substantial weakness in surveillance of polio. Strengthening of the polio specific surveillance network in the country remained a critical need for accelerated efforts for polio control in states and districts. Several additional measures particularly polio to be made a notifiable disease with mandatory reporting of all cases even from private practitioners were needed.[307]

3.17.2 Efficacy of Polio Vaccine in Tropical Region of India

Research on identifying the strains of polio virus prevalent in the country was successful in Bombay. In Bombay P. V Gharpure isolated the strains of virus in the country. These identified viruses were part of type campaign and of which 5 were typed: 4 types 1 and 1 type 2. Coxsackie viruses was isolated from 3 out of 20 faecal specimens positive for poliovirus by DD Banker.[308]

There were many studies conducted to understand the efficacy of OPV in tropical and temperate countries. One of the major findings from these studies was that polio antibody

[306] Sokhey, J. (1992). Poliomyelitis Surveillance in India, Special Article. *Indian Journal of Pediatrics*, 29.
[307]Sokhey, J. (1992). Poliomyelitis Surveillance in India, Special Article. *Indian Journal of Pediatrics*, 29.
[308] Freyclie, M.J. & Nielsen, J. (1955). *Incidence of poliomyelitis since 1920. In: Poliomyelitis*. Geneva: World Health Organization: Monograph Series, 26. (Retrieved from www.who.int)

response (seroconversions rates) after administration of trivalent oral polio vaccine was low in tropical region in many developing countries compared to temperate regions. [309]

Before the start of Pulse Polio Immunization program (PPI) in 1995 India witnesses a period of discussion on efficacy of oral polio vaccine in the tropical climactic conditions of India. Some of the major research works was done in South India medical college - Christian Medical College. Using the OPV vaccine many studies were done to understand the efficacy of OPV in India.[310]

In India serological studies to understand the efficacy of OPV were conducted to test the potency of polio vaccine in India. In the tropical climate of South India town of Vellore serological studies were undertaken. These studies examined the response of children to trivalent oral polio vaccine (OPV) in hot climate of India and various factors interfering with potency of vaccine.[311]

It was found that there were two reasons primarily which could reduce the potency of OPV vaccine 1) hot climate of region and inadequate logistics facilities for vaccine storage and transportation could reduce the potency of vaccine before administration to children, 2) prevalence of enteric infections in the environment of children in developing countries which interfere with immunity response of vaccine.

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[309] John, T.J., & Jayabal, P. (1972). Oral polio vaccination of children in the tropics. 1. The poor seroconversion rates and the absence of viral interference. *American Journal of Epidemiology*, 96:263-269; Poliomyelitis Commission, Western Region, Ministry of Health, Nigeria. (1966). Poliomyelitis vaccination in Ibadan, Nigeria during 1964 with oral vaccine (Sabin Strains): A Report, *Bulletin of the World Health Organization,* 34, 865-876; Ghosh.S., Kumari, S., Balaya, S., et al. (1970). Antibody response to oral polio vaccine in infancy, *Indian Journal of Pediatrics*, 7, 78-81.

[310] John, T.J. (2016). India's Research Contributions Towards Polio Eradication (1965-2015). *Indian Journal of Pediatrics,*53, (1-6).

[311] John, T.J. (2016). India's Research Contributions Towards Polio Eradication (1965-2015). *Indian Journal of Pediatrics,*53, (1-6).

The failure of vaccine detected in 1960s. The results of the study were not very promising and it was evident that OPV is not effective in producing the immunity against the polio virus in the tropical hot climatic condition as seen in cold climate.[312] The poor seroconversion response of children was affected by poor rates of vaccine virus uptake and not due to loss of potency of vaccine or interference of enteric virus.[313]

Furthermore, it was also evident from the studies that paralytic polio was occurring to children received three doses of trivalent OPV.[314] Intramuscular injection was another major risk for provoking paralytic polio in children. Provocation of polio was majorly increased in India after administering intramuscular injections of diphtheria pertussis-tetanus vaccine (DPT) on massive scale under EPI.[315]

3.18 Adaptation & Institutionalizing Polio Eradication in India – The Evolution of Pulse Polio Immunization Program (PPI)

The government of India was committed to achieve eradication of polio by 2000 by signing the 1990 declaration of the World Summit for Children. Indian was committed to achieve the goal of eradication through achieving sustained immunization coverage under

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[312] John, T.J., & Jayabal, P. (1972). Oral polio vaccination of children in the tropics. 1. The poor seroconversion rates and the absence of viral interference. *American Journal of Epidemiology,* 96:263-269; John, T.J. (2016). India's Research Contributions Towards Polio Eradication (1965-2015). *Indian Journal of Pediatrics*,53, (1-6).

[313] John, T.J. (1975). Oral polio vaccination of children in the tropics II antibody response in relation to vaccine virus infection. *American Journal of Epidemiology*, 102(5); John, T.J. (2016). India's Research Contributions Towards Polio Eradication (1965-2015). *Indian Journal of Pediatrics*,53, (1-6).

[314] Srinivasa, D. K. et al. (1997). Poliomyelitis trends in Pondicherry, South India, 1989-91. *Journal of Epidemiology Community Health*, 51(4), 443–448; Soudarssanane, M. B., Rotti, S.B., Srinivasa, D.K., & Ramalingam, G. (1993). Paralytic Poliomyelitis in Children Under 6 Years in Pondicherry: Community Survey. *Journal of Epidemiology Community Health*, 47(3) 210–214.

[315]John, T.J. (1998). Did India have the world's largest outbreak of poliomyelitis associated with injections of adjuvanted DPT? *Indian Journal of Pediatrics*, 35,73-5; John, T.J. (2016). India's Research Contributions Towards Polio Eradication (1965-2015). *Indian Journal of Pediatrics*,53, (1-6); Wyatt, H.V. (1985). Provocation of poliomyelitis by multiple injections. *Transactions of the Royal Society of Tropical Medicine & Hygiene*, 79, 355-8. (Retrieved from www.who.int); Srinivasa, D. K. et al. (1997). Poliomyelitis trends in Pondicherry, South India, 1989-91. *Journal of Epidemiology Community Health*, 51(4), 443–448.

routine immunization. However, EPI approach was considered as failure to control polio in most of the developing countries including India.[316]

India was already struggling with some of the major health problems of the decade apart from undernutrition and poverty. The momentum to start the NIDs in India in India required political will and leadership. It was not until 1995 that the national program on polio eradication was launched in India called 'Pulse Polio Immunization Program (PPI)."

There were four major factors considered internationally for India to initiate the mass immunization strategy of polio eradication in the country – 1) Polio was perceived as a disease that "cripples a complete generation" thus every country should implement it; 2) the disease was burden on government, parents and society; 3) For the international community all endemic countries were a constant threat; 4) India was a major concern with its large population density exporting the polio virus to the whole world.

The idea of pulse polio immunization program for eradication of poliomyelitis penetrated within the Union Government of India through launch of pilot study on polio immunization in the capital city of Delhi, India in 1994.

"Acute Poliomyelitis was a major health problem in children and post-polio residual disability was a common cause in older age groups in late 1980's and early 90's. Like many other hospitals, Kalwati Saran Children's Hospital, New Delhi (Pediatrics department of Lady Hardinge Medical College), one of the largest Pediatrics hospitals in the country, had a separate "Polio ward" for acute cases and a rehabilitation unit flooded with patients with post-polio disabilities. So undoubtedly polio was a leading health problem in the country for which we had a potent vaccine available and the disease qualified to be eradicated as a health priority."[317]

[316] John, T.J., & Vashishtha, M.V. (2013). Eradicating poliomyelitis: India's journey from hyperendemic to polio-free status. *Indian Journal of Medical Research*, 137,881-89; Sathyamala, C., Mittal, O., Dasgupta, R., and Priya, R. (2005). Polio Eradication Initiative in India: Deconstructing the GPEI. *International Journal of Health Services*, 35(2), 361-83.

[317] Interview

Polio became a priority for the Delhi government health minister, a medical doctor in 1994.[318] Strong advocacy for the polio immunization program in the country was done in India by Indian Academy of Pediatrics and Rotary International. A group of pediatrics from Maulana Azad medical college met the Delhi health minister and discussed the need of polio eradication efforts in the country. Rotary organization in the country was pushing the agenda of polio eradication by doing advocacy for the goal among the top political leaders and funders of India. Indian ministers of health officials were already participating in the major meetings of the rotary and WHO SERO meetings.[319] Rotary International was supporting the government of India's national immunization programme through its polio plus project through its large network of rotary clubs in various states of India.

Through these meetings Delhi health minister having not much prior knowledge on global polio eradication initiative and no particular interest in problem of disability was motivated to start a vertical polio immunization program.[320] It was more a political interest then a health interest as no political party had before initiated such health program in the country.

"In early 90's, an academic environment was created by Indian Academy of Pediatrics, wherein role of "pulse" strategy was discussed by experts in various fora. There were views for and against this new strategy. It was Delhi Govt., headed by a medical doctor as its health minister, which set the stage for Pulse Polio Immunization in 1994 with unprecedented participation by medical and non-medical staff, donor agencies and NGOs. The very next year Govt. of India took up the challenge as National Pulse Polio Program."[321]

Political will required for launching NID was generated within the state level ministry of Delhi by the health minister appointed in the year of 1995. The campaign received support and encouragement from political parties and many influential people not just from the ruling

[318] Dr. Harsh Vardhan was appointed as State Minister of Health in 1993. He launched the pilot project of Pulse Polio Immunization Programme in 1994
[319] Vardhan, H. (2014). *A Tale of Two drops*. Prabhat Prakashan.
[320] Vardhan, H. (2014). *A Tale of Two drops*. Prabhat Prakashan.
[321] Interview

government. The Delhi health minister took personal interests and efforts for launching the first polio NID campaign in the country. Strong mobilization and advocacy for the polio immunization campaign was done by the health minister. Strategic learning for implementing the NIDs in Delhi was gained from reviewing the polio eradication experiences of Brazil and Philippines similar in socio-economic and environmental conditions of India. The material on literature on such experiences was provided by WHO South East Asia Regional health, Dr John Andrus on request from the Delhi Health Minister.[322]

The pilot study of the program used the well-tested method of National Immunization Day (NID) as it was successful in other countries. NID were successful mass campaigns implemented over a short period (days to weeks) in which two doses of oral poliovirus vaccine (OPV) are administered to all children in the target age group, regardless of prior vaccination history, with an interval of 4-6 weeks between doses.[323]

The NID was restricted to geographical areas of Delhi State for political and operational factors. The initial idea was to launch of model NID in Delhi to be replicated to other states in the country. The polio immunization campaign was much more manageable in Delhi state and it was within the political jurisdiction of health minister. A structured plan was developed to administer polio vaccine to children in Delhi in a one-day polio immunization campaign. The planning and implementation of polio campaign was majorly collaborative effort of both specialists and other people from different sections of society.[324]

The first core group for planning of polio campaign included pediatrics later various specialists, administrators, management experts were involved. It also included political

[322] Vardhan, H. (2014). *A Tale of Two drops*. Prabhat Prakashan.
[323] Vardhan, H. (2014). *A Tale of Two drops*. Prabhat Prakashan.
[324] Vardhan, H. (2014). *A Tale of Two drops*. Prabhat Prakashan.

parties, university teachers, campaign donors, child specialist, social workers, voluntary organization, non-governmental organization, school children, government health workers, Delhi medical association, health and education departments, Indian Academy of Pediatrics and many others. The polio campaign suffered lack of funds since the start. No separate funds were given by the state government for the campaign. Initially funding for the campaign was provided by diverting hospital savings, later many voluntary donors funded the campaign. Polio was given so much emphasis that a separate department within the State Ministry of Health and Family welfare for planning and implementation of polit study on polio was created. Both enumeration of children and social mobilization of community was given more emphasis to implement the program more effectively. The polio campaign received guidance and assistance from both WHO and UNICEF. Rotary supported the whole campaign both financially and in implementation working in joint collaboration with the government. Rotary overwhelming provided support in various areas such as fund's mobilization, awareness drives, transport and volunteer support etc.[325]

On October 2nd, 1994 on the occasion of birth anniversary of India's father of the nation Mahatma Gandhi the polio immunization campaign was launched in Delhi. This date for the launch of polio immunization campaign was politically chosen. The pilot study was a major success in reaching the children in a single day along with immense community participation. India immunized around 1 million children up to age of 3 years alone in state of Delhi in a single day. Delhi was not the first place that state-wide polio immunization days were implemented in the country covering the targeted children in one single day. The states of Kerala and Tamil Nadu have already implemented such polio campaigns before. But Delhi pilot polio immunization campaign was taken as a model for replicating to the rest of the

[325] Vardhan, H. (2014). *A Tale of Two drops*. Prabhat Prakashan.

country motivated by political interests. Before the success of the Delhi polio campaign the BJP had plans for replicating the Delhi polio campaign in four of its ruling states in the country. But driven by political interests of leveraging the political gains from success of Delhi polio campaign the ruling party of government of India in 1995 launched the national level polio eradication program called it Pulse Polio Immunization Days. (PPIs).[326]

In South Asia India with second largest population in the world was a late entrant in implementing NIDs in 1995. China with its world largest population started implementing the NIDs in 1990s and by 1997 achieved polio free status.

In 1995 India launched NIDs first in only three states Tamil Nadu, Kerala and New Delhi and later extended to all the states of the country. Pulse polio immunization program involves mass administration of trivalent oral polio vaccine to all children zero to five years of age within a limited period of time, necessary to interrupt wild virus transmission. Every child under PPI was administered polio vaccine on two NIDs conducted six weeks apart. In the Indian context, this translated to gigantic management task of mobilizing resources, arranging logistics to make the vaccine available at 650,000 immunization posts (IPs) for administration of polio vaccine to a staggering 120 million children on each NID.[327] This also involved extensive social mobilization campaign to bring the target children on the day of NIDs to given polio drops. This was an enormous task not done in any country of the world.

PPI program policy framework and strategies were adapted and implemented similarly as done in other SERO countries. There were three pillars to the PPI program in India 1)

[326] Vardhan, H. (2014). *A Tale of Two drops*. Prabhat Prakashan.
[327] Arora, N.K. (1997-98). *AIIMS-INDIACLEN. Pulse Polio Immunization Program Evaluation.* Central Coordinating Team.

intersectoral approach, 2) community participation, 3) simplicity.[328] But later because of the epidemiological contextual factors a number of new innovative strategies were implemented in the country.

[328] Arora, N.K. (1997-98). *AIIMS-INDIACLEN. Pulse Polio Immunization Program Evaluation.* Central Coordinating Team.

4. POLIO PROGRAM IMPLEMENTATION

Period of Unprecedented Progress

India has conducted two National Immunization Days (NIDs) since 1995. By the beginning of the year 1998-1999 PPI cycle India had completed four cycles, a total of eight rounds of NIDs. Implementation attempts in India resulted in a substantial decline in reported cases.[329]

Progress made in India over a short period of three years was notable to the world community for two reasons - 1) In India, the second-largest populous country, was attempting in every NIDs cycle most extensive mass immunization campaign no other country in the world has done in a single day. 2) In three cycles of NIDs, India progressed from reaching more than 79 million children in 1995 to successfully vaccinating 134 million children in 1998.[330] It reduced reported cases from 24257 cases in 1988 to 4320 confirmed cases in 1998. The pool of genetic biodiversity of circulating polioviruses reduced considerably[331].

India's progress in the initial years was termed *extraordinary* and happened in a short period of consistently and rigorously implementing the global strategy of biannual NIDs. [332]

[329] Each cycle consists of two rounds conducted in the month of low transmission season of polio (December and January)
[330] NIDs in 1995 targeted children aged less than 3 years (three birth cohorts). The Government of India increased the target age group from less than 3 years to less than 5 years in 1996-97. In 1996 India increased the age thus in the 1996-97 and 1997-98, NIDs targeted children aged less than 5 years (five birth cohorts)
[331] Arora, N.K. (1997-98). *AIIMS-INDIACLEN. Pulse Polio Immunization Program Evaluation.* Central Coordinating Team.
[332] Arora, N.K. (1997-98). *AIIMS-INDIACLEN. Pulse Polio Immunization Program Evaluation.* Central Coordinating Team.

The visibility of the Pulse Polio Immunization program within a short period increased in the country because of a strong commitment from political leaders, providers and utilizers of the polio immunization.[333]

At the highest level for the policy makers (prime minister, central and state health ministers' secretaries), polio eradication was a worthy goal calling for optimal resources investment.[334] At the providers and community level, the consciousness of the slogan of *Polio Free India* was etched in their minds.

The Pulse Polio Immunization (PPI) program was designed highly vertical. One of the unique features that contributed to its success was the program's simplicity. The focus of the policymakers in designing the program was to make it simple in terms of availability, accessibility, affordability, and acceptability.

Simplicity was an essential prerequisite for the effective implementation of the program in the diverse socio-cultural milieu of India. Fixed booth or immunization posts were organized on Sundays (a day observed as a holiday in the country) where the vaccine is provided free of cost at a distance of 1 Km from homes. The NIDs was celebrated as a day festival across India from west to east and north to south. For the implementers and community characteristic of simplicity in the program helped in its better implementation and success.[335]

The beginning of the program was built on volunteerism. The spirit of volunteerism helped the program to grow as a people's program. The program's simplicity allowed ample

[333] Arora, N.K. (1997-98). *AIIMS-INDIACLEN. Pulse Polio Immunization Program Evaluation.* Central Coordinating Team.
[334] Arora, N.K. (1997-98). *AIIMS-INDIACLEN. Pulse Polio Immunization Program Evaluation.* Central Coordinating Team.
[335] Arora, N.K. (1997-98). *AIIMS-INDIACLEN. Pulse Polio Immunization Program Evaluation.* Central Coordinating Team.

space for volunteers to contribute to its functioning. The involvement of UNICEF & rotary organizations in implementing the polio program mobilized a diverse echelon of people from the society.

These non-health workers included teachers, students, religious leaders, medical practitioners, community leaders, and homemakers. Volunteers organized immunization booths, raised awareness through rallies and motivated families through interpersonal communications and public appeals. One of the critical aspects of social mobilization was the involvement of school children in raising awareness. School children rallies were organized nationwide to raise awareness of National Immunization Day and publicized polio-free India's goals. School children on the streets in urban areas and villages obtained extensive support for OPV vaccination in the country.[336]

The integration of the concept of a people's program unleased an immense spirit of volunteerism. Together with the school, children, teachers, and families participated highly. Helping in IEC campaigns disseminating the program messages, organizing NIDs, and bringing children of their neighbourhood or relatives to polio booths.[337] This created enormous support and popularity for the program among the masses. The program becomes a massive public health movement to achieve a common goal of eradicating the poliovirus from the country.[338]

[336] United Nations Children's Fund (UNICEF). (2003). *A critical leap to polio eradication in India*. UNICEF Publication.
[337] United Nations Children's Fund (UNICEF). (2003). *A critical leap to polio eradication in India*. UNICEF Publication.
[338] Arora, N.K. (1997-98). *AIIMS-INDIACLEN. Pulse Polio Immunization Program Evaluation.* Central Coordinating Team.

Implementing mass polio vaccination campaigns called for effective program management, effective intersectoral coordination and aggressive social mobilization.[339] These features were thoughtfully integrated into the program from the beginning. Policymakers gave vigorous implementation of these three program components considerable importance.

As part of the program strategy, decentralized planning was strongly emphasized since the beginning of the program. This gave implementers at the district and block level flexibility in program management and taking additional proactive measures to improve the program management and implementation.[340]

District and block-level managers considered flexibility in the program a crucial component to making a change to the program as per the community needs. The program was a coordinated activity dependent on the functionaries at various levels. Together with health workers, NGOs and leaders at the community level, district and block coordination committees were responsible for microplanning, coordination among diverse health and non-health stakeholders, logistics management, management of immunization booth activities and enumeration of families and tracking of non-seekers families and monitoring of program in different phases of the program (post-NIDs, inter NIDs and pre NIDs different phases)[341]

Since the program's early days, an effort was made to generate strong inter-sectoral coordination with the health department for the program's success. In the context of a lack of

[339]Arora, N.K. (1997-98). *AIIMS-INDIACLEN. Pulse Polio Immunization Program Evaluation.* Central Coordinating Team; Arora, N.K. (1998-99). *AIIMS-INDIACLEN. Pulse Polio Immunization Program Evaluation*. Central Coordinating Team.
[340]Arora, N.K. (1997-98). *AIIMS-INDIACLEN. Pulse Polio Immunization Program Evaluation.* Central Coordinating Team; Arora, N.K. (1998-99). *AIIMS-INDIACLEN. Pulse Polio Immunization Program Evaluation*. Central Coordinating Team.
[341] Arora, N.K. (1997-98). *AIIMS-INDIACLEN. Pulse Polio Immunization Program Evaluation.* Central Coordinating Team; Arora, N.K. (1998-99). *AIIMS-INDIACLEN. Pulse Polio Immunization Program Evaluation*. Central Coordinating Team.

human resources at the health department because of vacant positions, involvement of the non-health department was more crucial for the program's functioning.

"Participation and Coordination by different cadres of human resource was the unique feature of Pulse Polio Immunization (PPI) Program." [342]

In this effort, all those who were even remotely connected with PPI were prioritized to be involved in the program. At the district level/ block coordination, committees played a critical role in expanding and maintaining the inter-sectoral coordination. Participation of non-health partners was considered significant for achieving the goals of the program provider. These non-health departments got involved in social mobilization campaigns and the functioning of immunization posts on the day of NID. They provided a workforce for program activities and valuable inputs for efficient program planning, which the district and block level coordination committees acknowledged. Considering the enormity of diverse tasks required for proper functioning program activities, emphasis was given to building a diverse network of individuals and departments contributing to the planning and implementation of the PPI.[343]

Strong political support and association of NGOs in the planning and implementation processes was integrated into the program. Realizing the enormity of the goals and objectives of the PPI program, intersectoral coordination, community cooperation and participation were perceived as compelling reasons for its success. The involvement of NGOs and local leaders' support was part of the program strategy and considered an important bridge between the

[342] Interview
[343] Arora, N.K. (1998-99). *AIIMS-INDIACLEN. Pulse Polio Immunization Program Evaluation*. Central Coordinating Team.

community and program implementers. They contributed intensively to providing a supportive environment for community participation. [344]

The objective of the program management and engaging diverse stakeholders was to work in coordination as a team aligned to a worthwhile goal of polio eradication. However, at the implementation level, synchronizing polio action for India's huge population was a significant challenge. The program management involved performing diverse management tasks largely dependent on the efficacy of the state/district/block level functionaries and timely access to logistical resources. It also required constantly accessing the community's behaviour towards accepting the program and issues in achieving maximum coverage.

Several of the challenges and problems in the program were strongly felt and communicated by stakeholders. The implementers at the ground level confronted challenges of shortage of funding for social mobilization, transport and lack of flexibility in spending unspent funds for other programmatic needs. Supply of polio vaccine for NIDs was improved over the years by taking several measures such as - correct enumeration of the target population, monitoring of vaccine availability, timely procurement of vaccines, including procurement of additional vaccines if required from the nearest source, and using mobile teams. However, several gaps in health system capacity were affecting the timely and potent polio delivery of the vaccine to children. Adequate transport facilities were required to move the workforce and vaccines to the immunization posts, particularly in remote and difficult-to-reach hilly and tribal areas. Difficulties in managing vehicles needed for to and from movement on the day of NIDs were recognized as a significant problem. Particularly in remote and difficult-to-access hilly and tribal areas. The health department was profoundly dependent on other non–health

[344] Arora, N.K. (1997-98). *AIIMS-INDIACLEN. Pulse Polio Immunization Program Evaluation.* Central Coordinating Team; Arora, N.K. (1998-99). *AIIMS-INDIACLEN. Pulse Polio Immunization Program Evaluation*. Central Coordinating Team.

departments and NGOs for obtaining vehicles and sometimes requesting vehicles from community people. Some of the measures taken to improve the transport facilities were proactively recognizing the problems in availability and maintaining adequate transport facilities to improve smooth functioning on the day of NIDs. However, despite these efforts' problems remained in the management of transport. Lack of flexibility in using funds for transport and need for change in procedures for obtaining vehicles from private sources.[345]

There were significant concerns around the quality of vaccines at the time of administration and maintenance of the cold chain among the district and block level providers. Malfunctioning cold chain equipment's and frequent shortage of power supply in primary health centres (PHCs) contributed to the low potency of vaccines. The issue was raised by implementers at the district and block level and became a significant concern at the highest level among policymakers. Ensuring the quality of the polio vaccine was recognized as critical for achieving the goal of polio eradication. Introducing a vaccine vial monitor (VVM) was considered viable for quality assurance of the polio vaccine. It was an additional measure to monitor the vaccine quality before administering it to children and not a substitute for cold chain maintenance. It was also a piece of equipment to convince skeptical people about the safety and quality of the polio vaccine. Thus, providing training and maintaining clarity on its use as an additional monitoring measure was considered equally essential. Much of the emphasis was initially given to proper training in interpreting the VVM labels before giving them to children. However, lack of clarity among program managers remained an issue on the VVM label, not a substitute but additional measures. Most health workers, NGOs and leaders

[345] Arora, N.K. (1997-98). *AIIMS-INDIACLEN. Pulse Polio Immunization Program Evaluation.* Central Coordinating Team; Arora, N.K. (1998-99). *AIIMS-INDIACLEN. Pulse Polio Immunization Program Evaluation*. Central Coordinating Team.

lacked the skills to interpret and were fully aware of the significance of introducing VVM labels in the program.[346]

Inter-sectoral coordination with the local state electricity department was improved for maintaining cold chain maintenance. Local state electricity boards were a vital partner to assure an uninterrupted supply of power at PHCs and district vaccine stores for NIDs. However, maintaining the cold chain remained a huge problem among the providers. The broken-down cold chain equipment and repeated power failures were still reported. In most districts, the state electricity department was not an essential stakeholder in PPI program as it was not considered significant by district officials. [347]

Opportunities to review post-NIDs gaps and learn important lessons to improve implementation were limited. Program monitoring post-NIDs was negligible in most districts, limited to the compilation of reports. Regular meetings of the district and block-level coordination committees to make significant changes in program strategies before implementing NIDs were essential. However, a general perception developed in a few places among implementers that these meetings are just formality to be complete before NIDs. Coordination committee meetings were organized just before the NIDs providing less time to adequately implement significant changes to the NIDs. There were signs of early implementation fatigue among the district and field staff providers. Lack of sufficient supervisory staff support, lack of follow-up action and feedback, unrealistic targets and tasks, and extra work under official pressure were some early symptoms of implementation fatigue.[348]

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[346] Arora, N.K. (1998-99). *AIIMS-INDIACLEN. Pulse Polio Immunization Program Evaluation*. Central Coordinating Team.
[347] Arora, N.K. (1997-98). *AIIMS-INDIACLEN. Pulse Polio Immunization Program Evaluation.* Central Coordinating Team; Arora, N.K. (1998-99). *AIIMS-INDIACLEN. Pulse Polio Immunization Program Evaluation*. Central Coordinating Team.
[348] Arora, N.K. (1998-99). *AIIMS-INDIACLEN. Pulse Polio Immunization Program Evaluation*. Central Coordinating Team.

The message of the global goal of preventing polio disability has to reach the last person. Health workers, NGOs, and leaders implemented intense mobilization campaigns to raise awareness about the program. Since the beginning of the program, almost all the communications channels were effectively utilized. The IEC messages communicated to utilizers of immunization services were – the goal of polio eradication, the disability caused by polio disease and the benefits of the program, awareness of general child health, and information on NIDs. Media and interpersonal communication were the two main communication methods used to disseminate the program messages. The social mobilization focused social messaging more on fathers and elders of the family, considering the social dynamics of decision-making to vaccinate children within the Indian families.[349]

Effective social mobilization campaigns were considered essential strengths for the program's success. The strong messaging on "fear of polio disability" helped the community understand the benefit of the polio vaccination and the overall goal of eradication. The strategy of intense social mobilization campaigns helped generate cooperation and community participation in implementing the PPI. The community participated in disseminating the program's messages, tracking non-utilizers of PPI and contributing to IP activities. [350]

One of the challenges was of involvement of non-health officials in the program activities. Maintaining smooth coordination between non-health department workers, NGOs and leaders, and health workers was a difficult task at the implementation level.

[349] Arora, N.K. (1997-98). *AIIMS-INDIACLEN. Pulse Polio Immunization Program Evaluation.* Central Coordinating Team; Arora, N.K. (1998-99). *AIIMS-INDIACLEN. Pulse Polio Immunization Program Evaluation*. Central Coordinating Team.
[350] Arora, N.K. (1997-98). *AIIMS-INDIACLEN. Pulse Polio Immunization Program Evaluation.* Central Coordinating Team; Arora, N.K. (1998-99). *AIIMS-INDIACLEN. Pulse Polio Immunization Program Evaluation*. Central Coordinating Team.

Some non-officials believed that PPI is primarily a health department's responsibility and thought they did not have any prominent role in the program. This attitude indicated a lack of interest in participating, making them participate passively in the program. There was a lack of clarity on the role of NGOs and leaders and their need for involvement in the program planning process among most health workers and some district and block officers. Thus, the participation of NGOs and leaders was not considered necessary for program success. However, several NGO members perceived a need to involve them and leaders in the program activities with broader responsibilities.[351] Several measures were taken to improve the coordination with non-health departments, NGOs and local leadership. This included proactively involving them in planning and implementation, defining their specific responsibilities and recognizing their contribution.

The repeated cycles of NIDs biannually for a more extended period and the constant focus of government machinery on a single public health program are bound to experience inevitable management and socio-cultural problems. The program was both affordable and available at a distance of 1km. However, a large population of children were still missed from the program. Continued missing of children in every pulse polio immunization round maintained the risk of virus transmission. Poorly immunized children were a significant risk for future polio outbreaks. In the largest democracy of India, achieving 100 per cent coverage was a daunting task that resonated with some of the providers of the PPI program.

The fixed immunization booth strategy was immunizing 120 million children on each NIDs but still missing 10 million children annually. This maintained the continued virus transmission in the community among the poorly immunized children. This was also a

[351] Arora, N.K. (1997-98). *AIIMS-INDIACLEN. Pulse Polio Immunization Program Evaluation.* Central Coordinating Team; Arora, N.K. (1998-99). *AIIMS-INDIACLEN. Pulse Polio Immunization Program Evaluation*. Central Coordinating Team.

significant concern expressed by the district/ block functionaries, health workers, NGOs and leaders.[352]

Despite making the IPs available at the doorstep, the problem of non-utilizers increased with each PPI cycle. Several factors determined the specific category of populations' behaviour and prevented their access to the PPI program. Tracking inaccessible families has been recognized as a significant problem since the beginning of the program. Several measures were taken as part of the program strategy to identify and characterize the PPI program's difficult-reach populations to maximize the program's reach.[353] It was considered essential to track the non-seekers of the polio vaccine to reach the polio eradication goal.

Implementers made proactive efforts at all levels to address the barriers to PPI. Efforts were made to remove two types of inaccessibility to PPI - 1) Physical or geographical constraints experienced by people in access to health services, and 2) Improving the acceptability of PPI among the community. To identify difficult to reach, the non–utilizer's population were divided into four categories - barriers to affordability, availability, accessibility, and acceptability to immunization posts.

Characteristics of non-utilizers of the PPI program who were not utilizing the immunization service because of various accessibility, affordability, and availability determinants. Half of the non-utilizers were unaware of the PPI program and its benefits, and the other half were aware. They were also not seeking vaccination from routine immunization or utilizing other health services. Affordability of the program was mostly experienced by

[352] Arora, N.K. (1997-98). *AIIMS-INDIACLEN. Pulse Polio Immunization Program Evaluation.* Central Coordinating Team; Arora, N.K. (1998-99). *AIIMS-INDIACLEN. Pulse Polio Immunization Program Evaluation*. Central Coordinating Team.
[353] Arora, N.K. (1997-98). *AIIMS-INDIACLEN. Pulse Polio Immunization Program Evaluation.* Central Coordinating Team; Arora, N.K. (1998-99). *AIIMS-INDIACLEN. Pulse Polio Immunization Program Evaluation*. Central Coordinating Team.

children of daily wages workers of various types, beggar and agriculture labourers and slum dwellers. These groups of people perceived their children's health as necessary but coming to Immunization Posts (IPs) meant to them sacrificing their one-day wages essential for their daily survival. Availing of polio drops was difficult for children who were not at home on the day of NIDs, no one was at home to bring children to IPs, adults present at home were sick, and events at home (marriage, birth, death). Accessibility was a factor, especially for half of those who were aware of the benefits of polio drops and willing to provide them to their children. However, people were unavailable to come because IPs were inaccessible to people living in remote areas, people who are migrants and the tribal population. In certain places, climatic conditions also made access to IPs difficult. Acceptability of the PPI program was influenced among these groups of people because - people were followers of other systems of medicine, not willing to give polio drops to sick children and new-born infants, elders of the house (grandparents/ parents-in-law) influenced the decision, and not allowing to give polio drops or to go to IPs.[354]

Most of the non-utilizers were people experiencing problems in utilizing services but fully accepted the program's benefits. However, within the category of non-utilizers were a small proportion of 'hard core' non- utilizers who were unwilling to bring their children to IPs and refused to give the polio vaccine despite proactive efforts to remove barriers to accessing the program. Acceptability of the PPI program was influenced among these groups of people because of hearing negative things about PPI, bad experiences with the program in the past, and people having socio-cultural solid and religious beliefs.[355]

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[354] Arora, N.K. (1997-98). *AIIMS-INDIACLEN. Pulse Polio Immunization Program Evaluation.* Central Coordinating Team; Arora, N.K. (1998-99). *AIIMS-INDIACLEN. Pulse Polio Immunization Program Evaluation*. Central Coordinating Team.

[355] Arora, N.K. (1997-98). *AIIMS-INDIACLEN. Pulse Polio Immunization Program Evaluation.* Central Coordinating Team.

Proactive efforts were made to remove the barriers to reaching the immunization posts for families and the community, including those living in difficult-to-reach and outlying areas. Some of the proactive measures taken at various places included - bringing children to immunization posts (IPs); giving polio drops at home (mop-up operations); using mobile IPs teams for immunizing; making facilities for availing immunization just a day after NID day or in the following routine immunization day. Efforts were also made to strengthen the awareness and motivation of the community to bring children on their own for immunization against NIDs. Because of efforts, among most providers and community members, including mothers, the PPI program was considered a consumer-friendly program. For specific non-utilizers, coercion and sending legal orders were also used.[356]

Giving vaccine drops at home (mop-up operations) for two days after NIDs was one of the proactive measures, especially for non-utilizers of the PPI program. Mop-up operations were considered beneficial as an essential step by providers and facilitators for improving the coverage of PPI. For difficult-to-reach hilly and tribal areas mop -ups were considered essential where accessibility to IPs was a significant barrier. However, a general perception among government health workers was that the mop-up strategy would make the people reluctant who usually come for polio drops at IPs. They believed that the usual utilizers of the PPI would also prefer to get polio drops at home.[357]

Despite these additional efforts, the problem of missing targeted children to approximately 5 to 10 per cent of children on every NID remained significant. Extra efforts

[356] Arora, N.K. (1997-98). *AIIMS-INDIACLEN. Pulse Polio Immunization Program Evaluation.* Central Coordinating Team; Arora, N.K. (1998-99). *AIIMS-INDIACLEN. Pulse Polio Immunization Program Evaluation*. Central Coordinating Team.
[357] Arora, N.K. (1997-98). *AIIMS-INDIACLEN. Pulse Polio Immunization Program Evaluation.* Central Coordinating Team; Arora, N.K. (1998-99). *AIIMS-INDIACLEN. Pulse Polio Immunization Program Evaluation*. Central Coordinating Team.

were required to maximize coverage by reducing the proportion of non-utilizers of the PPI program.[358]

Political patronage to the program played a critical role in generating high visibility and acceptance of the program among the communities. An increasing trend was seen in families' participation in every PPI cycle bringing their children to the polio booths on their own. Particularly increased participation of the mothers bringing their children on their own to the polio booths was considered a sign of an absence of community fatigue. Mothers perceived PPI important program, both consumer-friendly and of high political priority. This was considered a positive sign neglecting the possibility of socio-cultural beliefs or social resistance preventing families from accessing the immunization drive.[359]

However, by the fourth cycle of the PPI program, the early signs of community fatigue became visible. The community started questioning the repeated cycles of PPI. Community fatigue was visible in people's questions – on why giving polio drops, again and again, every year and lack of clarity on how long the program will continue. Providers also raised concerns about press and media publishing news negatively influencing program implementation. Providers strongly felt that the press and media should act responsibly and restrain such news publishing. A focused and intensified social mobilization campaign was needed to prevent utilizers from becoming non-utilizers of the PPI program and increase its acceptability.[360]

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[358] Arora, N.K. (1997-98). *AIIMS-INDIACLEN. Pulse Polio Immunization Program Evaluation.* Central Coordinating Team; Arora, N.K. (1998-99). *AIIMS-INDIACLEN. Pulse Polio Immunization Program Evaluation*. Central Coordinating Team.

[359] Arora, N.K. (1997-98). *AIIMS-INDIACLEN. Pulse Polio Immunization Program Evaluation.* Central Coordinating Team; Arora, N.K. (1998-99). *AIIMS-INDIACLEN. Pulse Polio Immunization Program Evaluation*. Central Coordinating Team.

[360]Arora, N.K. (1997-98). *AIIMS-INDIACLEN. Pulse Polio Immunization Program Evaluation.* Central Coordinating Team; Arora, N.K. (1998-99). *AIIMS-INDIACLEN. Pulse Polio Immunization Program Evaluation*. Central Coordinating Team.

The intense IEC messaging also lacked clarity on the rationale for giving children repeated doses of the polio vaccine. The health workers, teachers and volunteers lacked clarity on the reasons for giving additional doses of polio and thus failed to communicate it correctly to the community. In several places, additional doses of polio vaccines were misperceived to prevent other diseases and provide good health for the children. Many mothers incorrectly perceived that polio drops were sufficient to prevent several illnesses for a year and that there was no need for getting any other vaccines provided under routine immunization (RI). A reinforced awareness campaign with short, simple messages stressing PPI's objectives and the need for an additional dose of OPV was considered essential.[361]

By the 1998-1999 cycle, the PPI program was highly popular and successful. Community participation was achieved through a strong IEC campaign and interpersonal communication. Intense participation of the community, school children, teachers, local leaders and NGOs in the program was visible in many areas indicating the acceptability of the benefits of public health programs among the masses. The PPI was considered to have become a people's program by most stakeholders. Inter-sectoral coordination among implementation agencies was needed to be emphasized more for involvement of diverse stakeholders in the planning and implementation of the program. Participation and cooperation among community and health workers improved the credibility and image of the health workers and health department. This also increased the expectation among the community to improve the quality of essential health services along with PPI services. However, gaps remained for ongoing other health programs, existing health facilities and availing vaccines through routine immunization creating a feeling of un-satisfaction among people. Improving the quality of the health service

[361] Arora, N.K. (1997-98). *AIIMS-INDIACLEN. Pulse Polio Immunization Program Evaluation.* Central Coordinating Team; Arora, N.K. (1998-99). *AIIMS-INDIACLEN. Pulse Polio Immunization Program Evaluation*. Central Coordinating Team.

system, such as transport, filling vacant positions, and improving cold chain maintenance, was also required to facilitate PPI program activities.[362] Although substantial success continued, extra efforts were essential to maximize the coverage to address the problem of missing children in each NIDs. Much of the significant policy shifts and innovative measures taken in subsequent cycles of PPI were done to reach the last child till the final eradication of polio.

4.2 Achieving the Last Milestone – Intensifying the NIDs

The intensive Pulse Polio Immunization (IPPI) program was viewed as a model for research translating into policy and policy to program and back to research model. As problems arise from the field – this was an effort to reach the hardest the difficult to reach children.

Indian Expert Advisory Group (IEAG) was formed in 1999. The group comprises experts from WHO and other international experts, Indian experts, national, state and district level government ministers and various other scientists and experts of India and from outside. The group meeting was held biannually, mainly in the capital city of Delhi, to review the status of the polio eradication program and implementation of polio eradication strategies in India and give recommendations for improving the quality of implementation.

By 1999 polio movement in the country was considered to be in the last lap of PPI cycles. The polio program in the country successfully vaccinated two doses of OPV to above 90 per cent in 1999.[363] Reaching the goal of complete immunization coverage PPI program entered the final stages of eradicating the poliovirus from the country.

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[362] Arora, N.K. (1997-98). *AIIMS-INDIACLEN. Pulse Polio Immunization Program Evaluation.* Central Coordinating Team; Arora, N.K. (1998-99). *AIIMS-INDIACLEN. Pulse Polio Immunization Program Evaluation*. Central Coordinating Team.

[363] Arora, N.K. (1998-99). *AIIMS-INDIACLEN. Pulse Polio Immunization Program Evaluation*. Central Coordinating Team.

The world was looking forward to the success of the polio eradication in the largest democracy. The eradication of polio was a global partnership of countries towards a common goal. The success of India was significant for other countries. India was considered to contribute a maximum number of confirmed poliomyelitis cases.

The national stakeholders also knew that India's consistent efforts were essential for the program's success in other Asian and African countries. Other Asian and African countries were looking for motivation from the success story of the polio program in India. India was taking the lead in the global polio eradication program. At the national level among polio program stakeholders there was no apprehension about achieving the deadline of polio eradication by 2000. They were confident that India would achieve polio-free status by the end of 2000.

"…… 'Yes, India can do it. India will be free from polio by the end of 2000 AD except some pockets like UP and Bihar. But it really depends on how intense and how well these immunisation activities are performed" pg. 97 [364]

The significant challenges to the polio-free India vision were two states of Uttar Pradesh (UP) and Bihar. The confidence in polio eradication by 2000 was low in these two states among national stakeholders. As the target date of 2000 polio-free was fast approaching, efforts were intensified to address the remaining implementation challenges to make the country polio-free.

Despite the unprecedented success in reaching the millions of children in four years of implementing the PPI program, many children were missed. The accessibility of the program depends on removing the geographic barriers to immunization booths and making people understand the importance of the program beyond their socio-cultural perceptions. Missing

[364] Arora, N.K. (1998-99). *AIIMS-INDIACLEN. Pulse Polio Immunization Program Evaluation*. Central Coordinating Team.

children in each NIDs became a reoccurring problem for the rest of the PPI cycles maintaining the risk of polio transmission.

Major policy shifts were taken in the 1999-2000 cycle with the decision to increase the number of immunization rounds in the country by the government of India. The Pulse Polio Immunization was renamed *Intensified Pulse Polio Immunization*.

This shift in program policy was an international directive followed by GOI rather than guided by the findings of an evaluation of the program at the district and block levels. There were two factors for this shift in policy. First, it resolved to eradicate poliomyelitis globally by 2000. World Health Organization (WHO), along with other partners, made a plan to accelerate polio efforts in the endemic countries. This plan was discussed and endorsed at the fifty second World Health Assembly in 1999.

> 1. URGES poliomyelitis-endemic Member States to accelerate eradication activities by conducting additional immunization rounds each year, on either a national or subnational basis; to improve the quality of national immunization days by ensuring that every child is reached; to implement house-to-house "mopping-up" campaigns; and to enhance surveillance by ensuring that all cases of acute flaccid paralysis are detected and promptly investigated" pg. 31[365]

The members of WHA, including India, were committed to accelerating polio immunization efforts in their countries. Second, India had a large pool of unvaccinated/missed children despite efforts to immunize children via NIDs and routine immunization. The two NIDs in low poliovirus transmission season (December and January) from fixed sites provided immunity for a few months, creating an absence of immunity in communities yearly.[366]

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[365] World Health Organization. (1999). *Fifty-Second World Health Assembly*. Geneva, WHA52/1999/REC/1. (Retrieved from www.who.int)

[366] Arora, N.K. (1998-99). *AIIMS-INDIACLEN. Pulse Polio Immunization Program Evaluation*. Central Coordinating Team; Arora, N.K. (1999-2000). *AIIMS-INDIACLEN. Pulse Polio Immunization Program Evaluation*. Central Coordinating Team.

Following the WHA direction, the technical consultative group (TCG) of WHO-SERO gave specific and direct recommendations to the countries to accelerate activities and increase to six rounds per year (four National Immunization Days (NIDs) and two Sub-National Immunisation Days (SNIDs). The new immunization strategy was called the 4+2 program.[367]

The government of India increased the frequency of immunization campaigns. The usual two national polio campaigns in December and January increased in the 1999-2000 cycle to four per year. Additionally, two Sub-National Immunisation Days (SNIDs) were conducted between February – March in eight high-risk states where paralytic polio cases were reported (including Assam, Bihar, Gujrat, Madhya Pradesh, Orissa, Rajasthan, Uttar Pradesh, and West Bengal)[368]

Intensification increased the number of polio cycles per year and infused significant change to the overall structure of the polio vaccination delivery services and monitoring.

The significant strategic change was house to house immunization strategy.[369] In each NID/SNID, after the completion of immunization posts activity on the first day, mobile vaccination teams visited houses for the next two days. This strategy ensure coverage by identifying un-immunized/missed children at home and giving them polio drops.[370]

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[367] Arora, N.K. (1999-2000). *AIIMS-INDIACLEN. Pulse Polio Immunization Program Evaluation*. Central Coordinating Team.

[368] Arora, N.K. (1999-2000). *AIIMS-INDIACLEN. Pulse Polio Immunization Program Evaluation*. Central Coordinating Team; Indian Expert Advisory Group (IEAG). (2000). *Final Conclusions and Recommendations,' The Third Meeting of Indian Expert Advisory Group for Polio Eradication*. New Delhi, India 26th May. (Retrieved from http://www.npspindia.org)

[369] House to house immunization conducted as part of Mop-ups campaigns to stop the final chains of poliovirus transmission in remaining pockets of virus transmission as an "end game" strategy. The house the house immunization during NIDs were conducted in response to reach the unimmunized population and thus are different in their purposes.

[370] Arora, N.K. (1999-2000). *AIIMS-INDIACLEN. Pulse Polio Immunization Program Evaluation*. Central Coordinating Team

In order to reach every targeted child and ensure the quality of the process in intensified polio cycles, two program innovations were introduced in India – a) Marking every child who has left a little finger with gentian violet solution who received polio drops; b) Marking of houses visited by vaccination teams[371]

Micro-planning was one of the essential features of this activity, where a detailed schedule of covering each house was planned. The planning involved mapping houses in high-risk areas along with logistic and financial planning. During the house-to-house visits, the vaccination teams check for the mark on the children's little fingers. House was marked with 'X' if the child was not at home or the parents refused to vaccinate. The vaccination team made two more visits to the house marked 'X' to convince and vaccinate children to ensure no child was missed. After this, the house was marked 'P'.[372]

The program implementers suggested the need for a house-to-house vaccination strategy earlier. One critical learning from earlier polio cycles was that the immunization booth-based approach was insufficient to reach non-utilizers and hard-to-reach populations. The primary intent for such change in the delivery of vaccines was to improve the quality of polio campaigns and maximize the coverage, particularly in the hard-to-reach communities.[373]

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[371] Arora, N.K. (1999-2000). *AIIMS-INDIACLEN. Pulse Polio Immunization Program Evaluation*. Central Coordinating Team; Indian Expert Advisory Group (IEAG). (2000). *Final Conclusions and Recommendations,' The Third Meeting of Indian Expert Advisory Group for Polio Eradication*. New Delhi, India 26th May. (Retrieved from http://www.npspindia.org)

[372] Arora, N.K. (1999-2000). *AIIMS-INDIACLEN. Pulse Polio Immunization Program Evaluation*. Central Coordinating Team; Indian Expert Advisory Group (IEAG). (2000). *Final Conclusions and Recommendations,' The Third Meeting of Indian Expert Advisory Group for Polio Eradication*. New Delhi, India 26th May. (Retrieved from http://www.npspindia.org)

[373] Arora, N.K. (1997-98). *AIIMS-INDIACLEN. Pulse Polio Immunization Program Evaluation.* Central Coordinating Team; Arora, N.K. (1998-99). *AIIMS-INDIACLEN. Pulse Polio Immunization Program Evaluation*. Central Coordinating Team; Arora, N.K. (1999-2000). *AIIMS-INDIACLEN. Pulse Polio Immunization Program Evaluation*. Central Coordinating Team.

The intensification and change in the polio drop delivery reduced the country's polio virus load. The program made significant achievements in October of 1999 by successfully interrupting the transmission of type II poliovirus. [374]

Globally the need for a high-quality surveillance system was increasing. It was considered essential for accurately mapping polio-virus transmission using acute flaccid paralysis (AFP) for screening cases. By the year 1997 program had developed a high-quality sensitive surveillance system for screening acute flaccid paralysis (AFP) cases. The surveillance system was developed under National Polio Surveillance Project (NPSP). It was a collaboration of the WHO-Government of India funded by Danida.

Since the program's start, polio surveillance indicators in India have achieved above the global benchmark level. This was a significant achievement of NPSP compared to other countries where it took many years to reach the global benchmark level. The AFP surveillance accurately defined the extent of wild virus transmission in India. [375]

4.3 Problems with Intensification of PPI

Intensification was adopted towards the final phase of eradication globally to interrupt wild poliovirus transmission in endemic countries where it was most persistent. India completed a polio intensified program in March of 2000. Between the years 1999 – 2000, India conducted the six cycles of immunization campaigns per year, which generally took place 4 -

[374] Indian Expert Advisory Group (IEAG). (2000). *Final Conclusions and Recommendations,' The Third Meeting of Indian Expert Advisory Group for Polio Eradication*. New Delhi, India 26th May. (Retrieved from http://www.npspindia.org)
[375] Indian Expert Advisory Group (IEAG). (2000). *Final Conclusions and Recommendations,' The Third Meeting of Indian Expert Advisory Group for Polio Eradication*. New Delhi, India 26th May. (Retrieved from http://www.npspindia.org)

to 6 weeks apart from October to March in the country. Globally and in India, expanding polio immunization frequency to wipe out the polio disease from the world was thought sufficient.

The 4+2 strategy outcomes were becoming visible at the field level. The house-to-house strategy was successful in reaching the missed children in high-risk states. Compared to last year, house-to-house visits increased the immunization coverage to 18 per cent, particularly in high-risk states of Uttar Pradesh, Bihar, Delhi and West Bengal.[376]

The house-to-house strategy was beneficial in covering households which were missed/dropping out of the immunization program. However, this strategy also made parents lethargic and reluctant to come to IPs who were earlier coming to fixed IP. There was a uniform decline in parents coming to fixed immunization posts. The general perception developed in communities that immunization teams would be coming to the house-made them reluctant to utilize the service at the immunization posts.[377]

In 2000 NIDs/SNIDs activity was increased from 3 to 7 days to ensure sufficient time for conducting quality house-to-house activity. In the middle and low burden zone, aggressive mop-ups of high quality were recommended.[378]

The burden of extra NIDs/SNIDs increased the financial budget and overall demand for OPV supply to endemic countries. Gaps in the financial budget to implement an accelerated

[376]Indian Expert Advisory Group (IEAG). (2000). *Final Conclusions and Recommendations,' The Third Meeting of Indian Expert Advisory Group for Polio Eradication*. New Delhi, India 26th May. (Retrieved from http://www.npspindia.org)
[377] Arora, N.K. (1999-2000). *AIIMS-INDIACLEN. Pulse Polio Immunization Program Evaluation*. Central Coordinating Team.
[378] Indian Expert Advisory Group (IEAG). (2000). *Final Conclusions and Recommendations,' The Third Meeting of Indian Expert Advisory Group for Polio Eradication*. New Delhi, India 26th May. (Retrieved from http://www.npspindia.org)

polio plan were one of the significant concerns among ministers of several countries expressed at the Fifty-Second World Health Assembly (WHA) in 1999.[379]

One of the significant impacts of increased NIDs rounds was on the global shortage of OPV supply in countries. Timely vaccine procurement for implementation of immunization campaigns became a big concern for countries to control poliovirus transmission, let alone eradication of diseases.[380]

Together with an improvement in coverage of routine immunization and an increase in the intensity of immunization cycles was thought sufficient to reach missed children and maintain the population immunity. However, the overall vaccination exercise became more rigorous. The burden of planning and management of polio programs increased immensely. The one-day activity organized on Sunday was extended to several days with house-to-house visits. The extended field-based activity required more time and paid incentives for volunteers. Working-class volunteers, especially the teachers, could not contribute. The volunteers started dropping off the program activities, and the responsibility of carrying out polio activity increased for health workers.

"Different types of frontline health workers participated in creating awareness, mobilisation of eligible children to polio booths, administration of polio drops in the booths, home to home visits etc. Their enthusiasm in successful implementation of PPI program did infuse some extra motivation and energy in them to perform extra work but considering the quantum of activities they did lag behind in optimally attending to their primary duties before, during and after National Immunization Days."[381]

[379] World Health Organization. (1999). *Fifty-Second World Health Assembly*. Geneva, WHA52/1999/REC/1. (Retrieved from www.who.int)
[380] Indian Expert Advisory Group (IEAG). (2000). *Final Conclusions and Recommendations,' The Third Meeting of Indian Expert Advisory Group for Polio Eradication*. New Delhi, India 26th May. (Retrieved from http://www.npspindia.org)
[381] Interview

The nature of the program changed from a people's program to a more institutionalized program with paid workers. The strategy was well understood and followed at India's block and district levels. Despite increase in logistics and operational problems.

The six rounds of house-to-house activity carried out after NIDs/SNIDs added to the program fatigue.[382]

"As a part of the movement I can say that in the beginning health workers were really motivated to work extra for a national goal because PPI program enhanced their visibility and respect in the community. However, with repeated cycles their energy levels declined gradually and they did suffer from 'Program fatigue'."[383]

The increase in the intensity of the booth-based approach and the house-to-house approach was still insufficient to reach migrant and hard-to-reach populations. The quality of house-to-house visits was better in rural areas compared to urban areas, where most rural migrants came to get work opportunities.[384] Weakness in social mobilization among the community about the immunization resulted in people's reluctance to visit immunization posts. The initial concern of providers and community fatigue with repeated PPI cycles became prominent with the high intensity of the PPI activity. The implementation fatigue became a concerning issue that required assessment of its factors at ground level.[385] Interest and enthusiasm were waning off with frustration on reaching the goal of eradication. The quality of the house-to-house strategy was good in rural areas, but in a large urban area, it was a

[382] Indian Expert Advisory Group (IEAG). (2000). *Final Conclusions and Recommendations,' The Third Meeting of Indian Expert Advisory Group for Polio Eradication*. New Delhi, India 26th May. (Retrieved from http://www.npspindia.org)
[383] Interview
[384] Indian Expert Advisory Group (IEAG). (2000). *Final Conclusions and Recommendations,' The Third Meeting of Indian Expert Advisory Group for Polio Eradication*. New Delhi, India 26th May. (Retrieved from http://www.npspindia.org)

[385] Arora, N.K. (1998-99). *AIIMS-INDIACLEN. Pulse Polio Immunization Program Evaluation*. Central Coordinating Team; Arora, N.K. (1999-2000). *AIIMS-INDIACLEN. Pulse Polio Immunization Program Evaluation*. Central Coordinating Team.

significant challenge because of the lack of a sufficient workforce. Despite the introduction of finger marking, over-reporting children immunized was typical.[386]

4.4 Missing the 2000 Goal Deadline for Polio Eradication

As is with any other global program, progress in the overall WHO region was essential for the success of the polio eradication program.

The WHO South-East Asia Region (WHO SEARO) started slowly implementing the NIDs in their respective countries in 1988. The Maldives was the first country to start the polio eradication program, followed by others and India in 1995. However, India became the last country in the SEARO to achieve the polio-free status (see table 1).

[386] Indian Expert Advisory Group (IEAG). (2000). *Final Conclusions and Recommendations,' The Third Meeting of Indian Expert Advisory Group for Polio Eradication*. New Delhi, India 26th May. (Retrieved from http://www.npspindia.org)

Table 1.

South-East Asia Region Polio Free Countries -Year Wise

Countries	Year of Last Polio Case
Bhutan	1986
Democratic	
People's Republic of Korea	1996
Timor-Leste	1999
Indonesia	1995
Maldives	1980
Myanmar	1996
Nepal	2000
Sri Lanka	1993
Thailand	1997
India	**??? 2014**

Source: World Health Organization (WHO) & Global Polio

Compared to other South East Asia countries, India was a late entrant in implementing national immunization campaigns. However, the substantial success achieved by India in the initial years of implementing the program was globally motivating for the overall success of the WHO SERO region.

In India number of laboratories that confirmed polio cases were dramatically reduced. Rapid progress resulted from efficient synchronization and management of NIDs activities,

sustained political commitment, unprecedented and extensive community participation, and strong commitment of implementers at the district and block level.[387] The success achieved in a short period was dramatically accentuated globally.

It was initially decided by the international community at WHA that the target year for interruption of poliovirus is 2000, followed by complete eradication of the virus by 2005 in all the WHO regions. Among the WHO South-East Region, India's progress was not only critical but essential for the success of the global eradication of polio. Globally, India's progress was considered essential for two factors – 1) India, with the largest population, was reporting half of the polio cases and was a persistent reservoir of poliovirus, and 2) India was importing the virus to other neighbouring countries.

By the middle of 2000, IEAG acknowledged the remarkable progress of the polio eradication program in India. The three areas where India's polio eradication achieved progress were - 1) India reported 265 polio cases in the year 2000, the lowest reported number of polio cases since the start of the program in 1995; 2) India's AFP surveillance continued the steady improvement achieving the accuracy required to detect the poliovirus transmission in the country by 2000. A steady increase in the non-polio AFP rate occurred from 1.45 in 1998 to 1.83 per 100,0000 children aged less than five years in 1999. The stool collection rate also exceeded 80 per cent in the first quarter of 2000 for the first time in the country; 3) India was the only country reporting type 2 wild poliovirus transmission in 1999 but by October 1999, type 2 wild virus transmission ceased to be reported in the country.[388]

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[387] Arora, N.K. (1999-2000). *AIIMS-INDIACLEN. Pulse Polio Immunization Program Evaluation*. Central Coordinating Team.

[388] Indian Expert Advisory Group (IEAG). (2000). *Final Conclusions and Recommendations,' The Third Meeting of Indian Expert Advisory Group for Polio Eradication*. New Delhi, India 26th May. (Retrieved from http://www.npspindia.org)

Evaluation and feedback from other agencies were the cornerstones of the programmatic changes implemented in the program. Some of the essential programmatic changes done within the program were the introduction of VVM vials, door-to-door immunization, reaching out to non-utilizers of the program, increasing the number of sub-national immunization days in some districts with high polio transmission and introducing house-to-house immunization and mop-up immunization by extending administration of polio drops to two days after NIDS.[389]

Hopes were high that polio program strategies implemented in the country would ultimately end poliovirus transmission by the end of 2000 in all the states of India.

However, despite this progress, India was not ready to call an end to the polio movement in the country and declared the country polio-free. The cases were still reported in the country; thus, India could not maintain the zero-performance required for three consecutive years to be declared polio-free. Globally, India became the only endemic country left in the WHO's South-East Asia Region (SEARO), unable to interrupt polioviruses' transmissions in 2000. It also delayed the WHO's SEARO regional polio-free certification.

Delayed in interrupting of the poliovirus transmission in India increased the risk of importation of poliovirus to other polio-free neighbouring countries. The global polio eradication initiative's goal of eradicating polio from the world was a gift from the twentieth century to the twenty first century. Globally, polio cases declined from 350,000 cases in 1988 to 7,071 from 1999 to 2000.[390] However, by the mid of 2000, it was clear that the global target

[389] Interview

[390] Indian Expert Advisory Group (IEAG). (2000). *Final Conclusions and Recommendations,' The Third Meeting of Indian Expert Advisory Group for Polio Eradication*. New Delhi, India 26th May. (Retrieved from http://www.npspindia.org); World Health Organization. (2001). *Global Polio Eradication Progress 2000, Department of Vaccines and Biologicals*, Geneva. (Retrieved from www.who.int)

date for interruption of transmission needed to be extended as in many countries' polio cases was still reported. Polio still crippled the health and lives of children in three WHO regions - South Asia Sub-continent, Sub-Saharan Africa and parts of the Middle East. Extraordinary progress was noted to be achieved in these three remaining WHO regions. The disease remained endemic in several corners of the world, continuing wild poliovirus transmission - Afghanistan, Egypt, India, Nigeria, Niger, Pakistan and Somalia.[391]

Missing the deadline of interrupting the polio virus by 2000 had significant implications for the global polio program and for achieving the global deadline of achieving a polio-free world by 2005. The deadline to finish the job of interrupting the poliovirus transmission was extended from 2000 to 2002, and to complete the global polio-free certification in subsequent years.[392] The hopes of achieving complete polio eradication by 2005 were high because of the *extraordinary* progress achieved in the remaining three polio-endemic WHO regions.

Fear of losing the motivation and sustained financial commitment of countries and polio funders, a meeting of polio partners was called at the United Nations headquarters in New York. On 27th September 2000, polio partners renewed the pledge to certify the world polio-free by 2005 at a Global Summit held at United Nations headquarters. Organized by the polio partners large gathering of around 250 individuals, including polio funders and ministers of countries where polio was endemic, came together to discuss how to overcome the challenges of making the world polio-free. The summit was a platform to reaffirm the global financial commitment to reaching the goal of polio eradication. Assuring the funders of achieving the

[391] Indian Expert Advisory Group (IEAG). (2000). *Final Conclusions and Recommendations,' The Third Meeting of Indian Expert Advisory Group for Polio Eradication*. New Delhi, India 26th May. (Retrieved from http://www.npspindia.org); World Health Organization. (2001). *Global Polio Eradication Progress 2000, Department of Vaccines and Biologicals*, Geneva. (Retrieved from www.who.int)

[392] National Surveillance Project A Government of India -WHO initiative. (2001). Technical Consultative Group on Vaccine-Preventable Diseases in South East Asia Region. *AFP Alert*, 5(6). (Retrieved from www.npspindia.org)

goal of a polio-free world by 2005, the then WHO director-general Gro Harlem Brundtland discussed the five-year strategic plan (2001 -2005). The strategic plan provided a roadmap to the polio-endemic countries for strengthening their efforts toward polio eradication. It reaffirms its goal to develop and sustain surveillance and laboratory systems in the countries for identifying the polio-infected areas. The plan had methods of laboratory containment of wild poliovirus stocks and developing a strategy to stop polio immunization after eradication certification. The strategic plan emphasized the need to conduct high-quality and effective immunization days. It also realized the need to strengthen and expand routine immunization services.[393]

4.5 Maintaining the Progress After 2000 and Reaching the Last Child

Implementation attempts globally by the end of 2000 made substantial progress towards achieving polio eradication worldwide. At the end of 2001, the share of the total polio-endemic countries reduced from 125 in 1988 to 20 in 2000 and to 10 in 2001. In 2001 total number of polio cases declined from 2979 to 480.[394] The region of EURO of WHO and the Western Pacific region was certified polio-free.

Globally battle against the poliovirus now has to be fought in the remaining endemic countries, including India. The countdown to a polio-free world was launched, and the global pressure became more intense on polio-endemic countries. The global strategy was decided, and all the resources were diverted to these eight countries.

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[393] World Health Organization. (2000). *Global Polio Eradication Initiative: strategic plan 2001-2005*. Geneva. (Retrieved from www.who.int)

[394] Indian Expert Advisory Group (IEAG). (2000). *Final Conclusions and Recommendations,' The Third Meeting of Indian Expert Advisory Group for Polio Eradication*. New Delhi, India 26th May. (Retrieved from http://www.npspindia.org)

After missing the global target for interrupting poliovirus transmission by 2000, India has only two years to stop polio transmission altogether. Nationally it was crucial for India two maintain the substantial progress achieved in program outcomes and address the remaining challenges in the country towards achieving the global target date. The significant challenges that needed to be addressed were - a) to address and improve weaknesses in AFP surveillance in a few states, b) to stop the transmission of poliovirus in endemic regions in the country, and c) to ensure the timely and adequate supply of funds and oral polio vaccine.[395]

India's remarkable progress in the polio eradication program was also differential progress within India. After the intensified strategy by the mid of 2000, the country was divided into three polio transmission zones – high burden zone (HBZ), middle burden zone (MBZ) and low burden zone (LBZ). The evaluation of the 4+2 strategy revealed that the states in the southern part of the country were emerging polio-free. However, the challenge remained to stop the transmission of wild poliovirus in four northern states of Delhi, Uttar Pradesh, Bihar and West Bengal. These were the states of high burden zone (HBZs) distinct because of their densely populated population and continuation of intense transmission of poliovirus. There were other states where the polio transmission was not intense but reported one or two cases of wild poliovirus cases in 2000, categorized into middle burden zone (MBZ) – Assam, Rajasthan, Gujrat, Madhya Pradesh, Punjab, Haryana, Orissa. The remaining states, including polio-free southern states, were categorized into low burden zone (LBZ). The epidemiological division of the country was considered necessary for deciding statewide and within-state endemic region-specific strategies for effective program implementation.[396]

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[395] Indian Expert Advisory Group (IEAG). (2000). *Final Conclusions and Recommendations,' The Third Meeting of Indian Expert Advisory Group for Polio Eradication*. New Delhi, India 26th May. (Retrieved from http://www.npspindia.org)

[396] Indian Expert Advisory Group (IEAG). (2000). *Final Conclusions and Recommendations,' The Third Meeting of Indian Expert Advisory Group for Polio Eradication*. New Delhi, India 26th May. (Retrieved from http://www.npspindia.org)

Improvement in accurately defining the extent of wild poliovirus was reported in most districts but was varied. However, in some weak-performing areas, surveillance systems needed strengthening. A practice to shift medical surveillance officers (SMOs) from one area to another due to a shortage of SMOs developed. In order to stop this practice and strengthen the AFP surveillance network in weak-performing areas, directives to appoint additional SMOs were given in 2000.[397]

The problem of ensuring adequate and timely funds and 620 million doses of OPV continued in the country in 2000- 2001[398]. It was critical to ensure appropriate doses for completing the SNIDs on time before NIDs were implemented. It required guaranteed procurement of OPV from vaccine suppliers and meticulous planning in the country to ensure adequate OPV doses for every round of SNIDs/NIDs in a year. The shortage of vaccine OPV doses was fulfilled from both Indian and international vaccine suppliers through UNICEF and set aside for both fall and winter SNIDs/NIDs. In cases of delays in an adequate supply of vaccines, the focus was on providing doses of vaccines to high-burden states for SNIDs.[399]

Micro-planning was considered critical for the success of polio immunization campaigns. It was a resource-intensive activity which required extensive mapping, particularly in high-risk areas, for its successful implementation. Adequate funds were necessary for logistical and financial support to develop and implement micro plans.[400]

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[397] Indian Expert Advisory Group (IEAG). (2000). *Final Conclusions and Recommendations,' The Third Meeting of Indian Expert Advisory Group for Polio Eradication*. New Delhi, India 26th May. (Retrieved from http://www.npspindia.org)

[398] Indian Expert Advisory Group (IEAG). (2001). *Recommendations of the Fourth Meetings of Experts for Polio Eradication,* New Delhi, India 30 January. (Retrieved from http://www.npspindia.org)

[399] Indian Expert Advisory Group (IEAG). (2000). *Final Conclusions and Recommendations,' The Third Meeting of Indian Expert Advisory Group for Polio Eradication*. New Delhi, India 26th May.(Retrieved from http://www.npspindia.org); Indian Expert Advisory Group (IEAG). (2001). *Recommendations of the Fourth Meetings of Experts for Polio Eradication,* New Delhi, India 30 January. (Retrieved from http://www.npspindia.org)

[400] Indian Expert Advisory Group (IEAG). (2000). *Final Conclusions and Recommendations,' The Third Meeting of Indian Expert Advisory Group for Polio Eradication*. New Delhi, India 26th May. (Retrieved from http://www.npspindia.org)

By 2001 total number of cases rose slightly in India from 265 in 2000 to 268 cases in 2001. However, geographically the distribution of polio-infected districts declined by 50 per cent, from 89 in 2000 to 63 in 2001.[401]

India's progress has been considered remarkable and steady since 1995, with the decrease in cases and the shrinking of districts with poliovirus transmission in the country. The years from and after 2000 were critical for India's performance to reach the deadline of polio eradication.

The year 2001 was considered crucial for planning the polio eradication activities. Hopes were high among the polio experts to achieve the job of interrupting the polio transmission in less time. The country needed defined targets, determination and conviction to achieve the polio-free goals.[402]

In order to end the polio transmission in the country apart from SNIDs/NIDs, a mopping up drive was planned at a large scale all across the country from January 2001[403]. This end-game strategy involving house-to-house mop-up immunization was introduced in-country as poliovirus transmission was limited to well-defined pockets[404]. The end game strategy of mopping up was to reach every child in areas to stop the transmission of poliovirus. More focus was given to areas where wild poliovirus transmission was persistent and in clusters of polio-

[401] National Surveillance Project A Government of India -WHO initiative. (2002). Polio Eradication Initiative: Progress & Priorities. *AFP Alert*, 6(2). (Retrieved from www.npspindia.org).
[402] Indian Expert Advisory Group (IEAG). (2001). *Recommendations of the Fourth Meetings of Experts for Polio Eradication,* New Delhi, India 30 January. (Retrieved from http://www.npspindia.org)
[403] Indian Expert Advisory Group (IEAG). (2001). *Recommendations of the Fourth Meetings of Experts for Polio Eradication,* New Delhi, India 30 January. (Retrieved from http://www.npspindia.org)
[404] Indian Expert Advisory Group (IEAG). (2000). *Final Conclusions and Recommendations,' The Third Meeting of Indian Expert Advisory Group for Polio Eradication*. New Delhi, India 26th May. (Retrieved from http://www.npspindia.org); Indian Expert Advisory Group (IEAG). (2001). *Recommendations of the Fourth Meetings of Experts for Polio Eradication*, New Delhi, India 30 January. (Retrieved from http://www.npspindia.org)

compatible cases. Pre-emptive mop-up activities were also conducted in selected districts of high burden states of UP, Bihar and West Bengal from March to May 2001.[405]

However, some areas of the country reported implementing low-quality mopping up in 2000. This practice in the country was criticized as it compromised the core objective of this end-game strategy.[406] Mopping up as an end game strategy required meticulous microplanning, budgeting and training. However, its quality execution was critical for achieving the program targets as the whole mopping-up exercise was resource-intensive and could not be repeated frequently.

The polio experts underscored the discrepancies in implementing poor quality mopping-up activity in the country.[407] The problem was deemed urgent to clear the confusion on the central objective of mopping up as the poor quality of this activity was disadvantageous to program achievements gained so far and brought more damage to the program.[408] High-quality mopping-up exercises were considered necessary to reach the targeted children in defined areas of the country and achieve the 2002 global target of the last case of polio. Particularly enhancing the quality and ensuring implementation of high-quality mops-up activity was highly crucial for the success of this strategy in high-burden districts considered to be a risk factor of delaying the entire national polio program.[409]

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[405] Indian Expert Advisory Group (IEAG). (2001). *Recommendations of the Fourth Meetings of Experts for Polio Eradication,* New Delhi, India 30 January. (Retrieved from http://www.npspindia.org)

[406] National Surveillance Project A Government of India -WHO initiative. (2001). *Mopping-up: The critical issues*. *AFP Alert*, 5(1). (Retrieved from www.npspindia.org)

[407] National Surveillance Project A Government of India -WHO initiative. (2001). *Mopping-up: The critical issues*. *AFP Alert*, 5(1). (Retrieved from www.npspindia.org).

[408] National Surveillance Project A Government of India -WHO initiative. (2001). *Mopping-up: The critical issues*. *AFP Alert*, 5(1). (Retrieved from www.npspindia.org).

[409] Indian Expert Advisory Group (IEAG). (2001). *Recommendations of the Fourth Meetings of Experts for Polio Eradication,* New Delhi, India 30 January. (Retrieved from http://www.npspindia.org); National Surveillance Project A Government of India -WHO initiative. (2001). *Mopping-up: The critical issues*. *AFP Alert*, 5(1). (Retrieved from www.npspindia.org).

After 2001, compliancy and providers' fatigue were set in, and the country's enthusiasm to achieve polio eradication by 2005 was low after missing the deadline of 2000. Sub-optimal quality of SNIDs/NIDs was reported not only from high burden states but also from polio-free and low burden states.[410] The implications on program progress and quality of implementation became more apparent in the following years when significant setbacks to the program occurred in the history of the polio program journey in India since 1995.

4.6 Localized Reservoirs of Poliovirus

The program achievements gained by the year 2000 in the country were crucial to maintaining in the years 2001 and 2002 to complete the tasks for polio-free India as soon as possible. India was hopeful of envisaging the possibility of interrupting the polio virus transmission in the country by the end of 2002. Mopping up activity was planned for areas still reporting virus transmission to achieve complete eradication by low transmission season from February-May in 2002.[411] Two epidemiological reasons gave hopes for achieving polio-free status - 1) continuous decline in transmission of polio in low season; 2) decrease in the biodiversity of type 1 and type 3 polioviruses in the country. [412]

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[410] Indian Expert Advisory Group (IEAG). (2000). *Final Conclusions and Recommendations,' The Third Meeting of Indian Expert Advisory Group for Polio Eradication*. New Delhi, India 26th May. (Retrieved from http://www.npspindia.org)

[411] High quality mopping up activity continued to be a prominent strategy from 2001 to 2002 to stop transmission in endemic areas and non-endemic areas where poliovirus was reintroduced. (National Surveillance Project A Government of India -WHO initiative. (2002). Polio Eradication Initiative: Progress & Priorities. *AFP Alert*, 6(2). (Retrieved from www.npspindia.org); Indian Expert Advisory Group (IEAG). (2000). *Final Conclusions and Recommendations,' The Third Meeting of Indian Expert Advisory Group for Polio Eradication*. New Delhi, India 26th May. (Retrieved from http://www.npspindia.org)

[412] Polio transmission in low seasons reduced between February 1999 – July 2001 from 14 states in 1999 to 10 states in 2000 to 3 states in 2001; Biodiversity of type 1 and type 3 poliovirus decreased particularly the polio virus type 1 (P1) biodiversity reduced from 8 circulating P1 lineages in 2000 to 3 lineages in 2001 (Indian Expert Advisory Group (IEAG). (2000). *Final Conclusions and Recommendations,' The Third Meeting of Indian Expert Advisory Group for Polio Eradication*. New Delhi, India 26th May. (Retrieved from http://www.npspindia.org))

With its remarkable success globally accepted, India reached a stage where wild poliovirus transmission was limited to few defined pockets within the country. This was advantageous for the focused implementation of program strategies addressing the gaps in these defined high-burden areas. However, these pockets of persistent poliovirus transmission were equally challenging for sustaining the overall progress of the national program.

The country's endemicity of poliovirus and progress in program performance was widely varied. This variation has been visible since the start of the PPI program. Regional variations in program performance were categorized after the 1998-1999 cycle into better-performing and poor-performing regions. Poor performing regions included eight high-risk states – Uttar Pradesh, Bihar, Orissa, Rajasthan, Madhya Pradesh, Gujarat, West Bengal and Assam.[413]

The poor-performing regions included high-risk states where a maximum number of poliovirus-related AFP cases were reported. The health department was not implementing the program as per the vision, and there was apathy among the providers at all levels. In these states, few changes were made to micro plans by health providers at district and block level states over the years. Efforts were not made to involve and strengthen the partnership with non-health partners, NGOs, and local leadership in the planning and implementation of the program. Problems in availing, transport, cold chain maintenance, human resources and gaps in program implementation were not perceived, and if recognized, no efforts were made to improve the system. Opportunities to proactively implement changes to the program were neglected among the providers. The program providers in poor-performing states focus more on 'coverage' rather than on putting efforts to reach all segments of the target population to administer drops

[413] Arora, N.K. (1998-99). *AIIMS-INDIACLEN. Pulse Polio Immunization Program Evaluation*. Central Coordinating Team; Arora, N.K. (1999-2000). *AIIMS-INDIACLEN. Pulse Polio Immunization Program Evaluation*. Central Coordinating Team.

of polio. Thus, providers often reported claims of achieving over 100 per cent coverage. There was an imperative need to improve and strengthen program planning and implementation strategies in poor-performing regions of the country.[414]

The overall performance of the country was focused on poor-performing countries. In this process of achieving substantial progress new challenge in the form of a localized reservoir for poliovirus emerged in India. In India, the virus set its roots in the two poorest and most densely populated regions in the country's northern belt – the states of Uttar Pradesh and Bihar. In a country of vast democracy and varied regional inequality, the epidemiology of wild poliovirus and its transmission showed very distinct features in two of these regions. Both the states had very high population density and were epidemiologically the highest-burden zone. The remarkable progress achieved in eradicating polio in India had exceptions in these two northern states, Uttar Pradesh and Bihar.

The situation in India was unique, whereas the endemic circulation of wild poliovirus was stopped in the rest of India. However, the states of UP and Bihar were becoming a source of importation of poliovirus to other states.[415]

Away from the global target date, the country needed to finish the job as quickly as possible. The prominent hindrance towards achieving polio-free status were these two high-burden states of Uttar Pradesh and Bihar. These two states were seen as a significant risk factor for initiating re-infection in other states of the country. Achieving complete eradication was considered

[414] Arora, N.K. (1998-99). *AIIMS-INDIACLEN. Pulse Polio Immunization Program Evaluation*. Central Coordinating Team; Arora, N.K. (1999-2000). *AIIMS-INDIACLEN. Pulse Polio Immunization Program Evaluation*. Central Coordinating Team.
[415] Indian Expert Advisory Group (IEAG). (2003). *Seventh Meeting of the India Expert Advisory Group for Polio Eradication Sub-Group Meeting*, Lucknow, Uttar Pradesh, India, 24-25 February. (Retrieved from http://www.npspindia.org)

crucial as there was a significant risk to overall program progress in other states from these two-endemic poliovirus reservoirs. [416]

Among these endemic states, UP, in particular, was a significant risk factor and cause of concern. The state of UP reported the maximum number of cases every year since the start of the program in 1995 compared to Bihar and other high burden and middle burden states. UP was infecting not only other states within India. However, it was also the source of risk of importing poliovirus to other border neighbouring countries and other polio-free countries.[417]

The complexities and uniqueness of the UP state were distinct. The state is densely populated in India and divided into three parts Eastern UP, Central UP and Western UP. It was not the whole of UP state was an endemic reservoir of wild poliovirus. However, within the state, there were few endemic districts in the western part of UP where the continuation of virus transmission was persistent. Western UP was explicitly targeted to decrease polio transmission through the combination of strategies - SNIDs/NIDs, mopping up activities, and high-quality routine immunization to completely stop any remaining chains of transmission by 2003.[418]

Despite hopes to achieve the global target during 2000-2002, the country's optimism of achieving polio eradication by 2005 was low. It was apparent in the subsequent year as major setbacks occurred, particularly in northern belt states to the program's implementation in the

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[416] The share of districts infected due to imported virus increased from only 1 district out 89 infected districts in 2000 to 20 districts out of 63 infected districts in 2001. This was major cause of concern for overall progress achieved in the country. (Indian Expert Advisory Group (IEAG). (2003). *Seventh Meeting of the India Expert Advisory Group for Polio Eradication Sub-Group Meeting*, Lucknow, Uttar Pradesh, India, 24-25 February. (Retrieved from http://www.npspindia.org); National Surveillance Project A Government of India -WHO initiative. (2002). Polio Eradication Initiative: Progress & Priorities. *AFP Alert*, 6(2). (Retrieved from www.npspindia.org))

[417] Imported cases from UP were reported in China in 1999, Georgia and Bulgariain 2001 based on genetic evidence. (National Surveillance Project A Government of India -WHO initiative. (2002). Polio Eradication Initiative: Progress & Priorities. *AFP Alert*, 6(2). Retrieved from www.npspindia.org))

[418] National Surveillance Project A Government of India -WHO initiative. (2002). Polio Eradication Initiative: Progress & Priorities. *AFP Alert*, 6(2). (Retrieved from www.npspindia.org)

country. The intense poliovirus transmission in Uttar Pradesh and its risk of importation to other polio-free states and countries became a central issue in India and globally.

5. CONTEXTUAL POLIO PROGRAM CHALLENGES

Global and Local Concerns

The execution exercises are more complex than making strategies for immunization programs. In India's National Immunization Days (NIDs), unprecedented public health development was implemented across the country. But implementing pulse polio immunization (PPI) program in largest democracy was an elaborated management exercise involving intense coordination at all levels to give polio drops to the targeted children. Immunization programs require not only a timely supply of vaccines but also the existence of basic health infrastructure to sufficiently deliver the polio vaccines. It required program management skills and the participation of other non-health departments and people from the community to effectively provide the polio vaccine to the last child in the country. Administering the polio vaccine to the beneficiaries of each NIDs achieved substantial progress in the initial years. But with each cycle of PPI in the country, the challenges in implementing the program in the diverse geographical and socio-cultural environment become more visible, requiring new strategies to effectively immunize children in the country to eliminate poliovirus from the country.

4.7 The Outbreak of the Decade in Uttar Pradesh

"India, and in particular Uttar Pradesh, are the number one priorities for stopping transmission of the polio virus around the world", says WHO's director-general Dr Gro Harlem Brundtland.'[419]

So, what were the factors which made a state in the northern belt of India a global concern?

By the year 2003 India became the number one priority globally for the success of the global polio eradication initiatives. The above statement by the WHO director-general was

[419]World Health Organization. (2003). *WHO Director-General Calls India 'number 1'Polio Eradication Priority In India*. Media Release, April, 7. (Retrieved from www.who.int)

issued in response to the polio outbreak that occurred in Uttar Pradesh in the year 2002. All the global attention was focused on India. Symbolically epidemics had huge implications for the public health program. In the global eradication program, outbreaks are taken very seriously as they had huge implications not only on the progress achieved so far. But also lower the motivation and trust of people and funders involved with the program often lead to financial instability. This concern was reflected in the WHO- director-general statement which urges financial support.

"The support of the international community has never been more crucial than it is today," said Dr Brundtland.[420]

"We need donors to fill the US$ 275 million funding gap we face globally so that all activities can go ahead as planned. The generosity of the international community, and the successful partnership that has been formed with polio-infected countries, are crucial to ensuring the success of this initiative." [421]

This was not the only outbreak Uttar Pradesh experienced since the launch of the PPI program in the country. Uttar Pradesh was always prone to polio outbreaks even before the start of the PPI program. In the year 1988 Uttar Pradesh experienced an epidemic. By 2000 in Uttar Pradesh, three consecutive polio outbreaks occurred starting in 1997. In 1999 Uttar Pradesh experienced a large outbreak of polio of type III in 1999.

After 2000 all poliovirus strains detected in the country originated from UP.[422] Uttar Pradesh became a persistent reservoir of polio cases. The poliovirus remained in the endemic reservoirs of the state and enter the neighbouring states and areas when the conditions were conducive for local spread.

[420] World Health Organization. (2003). *WHO Director-General Calls India 'number 1'Polio Eradication Priority In India*. Media Release, April, 7. (Retrieved from www.who.int)
[421] World Health Organization. (2003). *WHO Director-General Calls India 'number 1'Polio Eradication Priority In India*. Media Release, April, 7. (Retrieved from www.who.int)
[422] AFP Alter (2002). National Surveillance Project A government of India -WHO initiative, 6(2), March- June

The 2002 resurgence in the number of polio cases of poliomyelitis in Uttar Pradesh was massive globally because India that year contributed to 84 per cent (1593) of the global total of cases and Uttar Pradesh alone had 78 (1236) per cent of India's cases.[423] This was a major outbreak of type 1 poliovirus centred in central and eastern Uttar Pradesh spreading to other states.

Multiple lineages of poliovirus were continuously circulating in reservoir areas of UP. These reservoir areas were a continuous risk for the polio-free areas in the country, particularly for the neighbouring states of UP.[424] The virus receded to these endemic reservoir regions when epidemiological conditions were non-conducive and spread to neighbouring regions and states when the immunity gap occurred.[425] These conducive epidemiological conditions developed in UP made the 2002 epidemic impact more severe for the overall progress of the eradication program in the country and globally.

The outbreak was a major resurgence of type 1 poliovirus cases in central and eastern UP. In 2002 outbreak of poliovirus was located in several states across India. The transmission of type 1 wild poliovirus was more than type 3 wild poliovirus.[426]

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[423] National Surveillance Project A Government of India -WHO initiative. (2002). Polio Eradication Initiative: Progress & Priorities. *AFP Alert*, 6(2). (Retrieved from www.npspindia.org); Indian Expert Advisory Group (IEAG). (2003). *Seventh Meeting of the India Expert Advisory Group for Polio Eradication Sub-Group Meeting*, Lucknow, Uttar Pradesh, India, 24-25 February. (Retrieved from http://www.npspindia.org)

[424] The multiple lineages of type1 and type 3 virus's circulation continued in UP because almost 10 percent of children with non-polio AFP in UP received 3 or fewer doses of OPV from the past several years and this continued and increased to 16 percent in 2002 causing outbreak. (National Surveillance Project A Government of India -WHO initiative. (2002). Polio Eradication Initiative: Progress & Priorities. *AFP Alert*, 6(2). (Retrieved from www.npspindia.org))

[425] National Surveillance Project A Government of India -WHO initiative. (2002). Polio Eradication Initiative: Progress & Priorities. *AFP Alert*, 6(2). (Retrieved from www.npspindia.org).

[426] The type 1 (1229) poliovirus cases were reported from in UP, Bihar, West Bengal, Gujrat, Delhi, Haryana, Madhya Pradesh, Jharkhand, Rajasthan, Uttaranchal, Maharashtra, Orissa, Jammu Kashmir, Chhattisgarh, Chandigarh. The type 3 poliovirus cases were reported from (94 cases) Uttar Pradesh (82), Delhi, Uttaranchal, Haryana. Polio cases were reported as result of direct exportation of poliovirus from Uttar Pradesh were – West Bengal, Rajasthan, Haryana, Gujrat, Madhya Pradesh, Jharkhand and Uttaranchal. (National Surveillance Project A Government of India -WHO initiative. (2002). Polio Eradication Initiative: Progress & Priorities. *AFP Alert*, 6(2). (Retrieved from www.npspindia.org); Indian Expert Advisory Group (IEAG). (2003). *Seventh*

The transmission of poliovirus spread from central and eastern UP into western Bihar the endemic transmission continued in Bihar.[427] The polio virus was imported to a few polio states but there was no local spread (Jharkhand, Madhya Pradesh, Haryana, Rajasthan and Maharashtra) resulting in some polio cases.[428] After spreading to West Bengal, Gujrat, and Delhi states type 1 poliovirus caused an outbreak and was re-introduced in these states.[429]

The intensity of the 2002 epidemic was high enough to spread to the neighbouring countries. Three factors created the conditions necessary for the resurgence of poliovirus to move out of endemic reservoirs - 1) failure to interrupt virus transmission in remaining pockets of UP during the year 2001, 2) A large cohort of unvaccinated children in central and eastern UP which got nurtured from late 2001 to 2002. This created a necessary immunity gap for the occurrence of the outbreak, the poliovirus spread to other areas from endemic reservoirs[430] and; 3) persistence high endemic transmission of type 1 and type 3 poliovirus in western UP.

The situation in India was very unique in northern states compared to the dramatic progress made by the PPI program in the southern states. Media reports in the country started reporting widely on the growing concern about the failure of the polio eradication program in

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Meeting of the India Expert Advisory Group for Polio Eradication Sub-Group Meeting, Lucknow, Uttar Pradesh, India, 24-25 February. (Retrieved from http://www.npspindia.org))

[427] Both UP and Bihar were endemic reservoir of wild polio virus. During the 2002 endemic transmission continued and resulted in increased in number of cases. But compared to UP in Bihar the quality of SIA was high enough to prevent widespread local transmission.

[428] Direct exportation of polio virus resulted in few polio cases but the high immunization status prevented re-establishment of virus transmission in these areas. High immunization status failed the local spread of virus during the peak year of transmission. (National Surveillance Project A Government of India -WHO initiative. (2002). Polio Eradication Initiative: Progress & Priorities. *AFP Alert*, 6(2). (Retrieved from www.npspindia.org))

[429] National Surveillance Project A Government of India -WHO initiative. (2002). Polio Eradication Initiative: Progress & Priorities. *AFP Alert*, 6(2). (Retrieved from www.npspindia.org)

[430] In central and Eastern UP percentage of children with non-polio AFP who received 3 or fewer doses of OPV increased from 2001 (9 percent) which increased in 2002 (32 percent). This created a pool of vaccination children resulting in outbreak in 2002. (National Surveillance Project A Government of India -WHO initiative. (2002). Polio Eradication Initiative: Progress & Priorities. *AFP Alert*, 6(2). (Retrieved from www.npspindia.org))

Uttar Pradesh and Bihar.[431] During the intensified PPI program (1999) government made efforts to reach every child in UP and Bihar implementing multiple supplementary immunization (SIAs), intensified national immunization campaigns and pre-emptive rounds. But the Uttar Pradesh outbreak in 1999 in the midst of implementing intensified pulse polio immunization was a major setback for the progress of the program in the state. The persistence of poliovirus exclusively in UP and Bihar raised doubts about the eradication strategies and potency of OPV used in these two states.

In the southern states, there was dramatic progress to interrupt the virus transmission[432] which was not seen in these two states.[433] In these two states, the transmission of poliovirus was not once interrupted since the start of the Pulse Polio Immunization program in 1995.

The media reports and widespread discussion on the failure of the polio program in UP and Bihar concerned the national-level polio experts.[434] The progress achieved in the two states was remarkable enough for the Government of India (GOI) to deny the growing concerns on failing of eradication strategy and OPV potency in these two states. Both decline in the number of cases and the shrinking of polio-infected districts made the government hopes to see similar success in UP and Bihar as was achieved in the southern states of the country.[435]

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[431] National Surveillance Project A Government of India -WHO initiative. (2001). Are we failing in UP and Bihar? *AFP Alert*, 5(4). (Retrieved from www.npspindia.org);Uttar Pradesh has largest number of polio cases. (2000, November 4). *The Times of India*. (Retrieved from ProQuest Historical Newspapers Database, www.proquest.com)

[432] The proportion of polio cases were reported among the children vaccinated with three or more doses of polio. (National Surveillance Project A Government of India -WHO initiative. (2001). Are we failing in UP and Bihar? *AFP Alert*, 5(4). (Retrieved from www.npspindia.org))

[433] National Surveillance Project A Government of India -WHO initiative. (2001). Are we failing in UP and Bihar? *AFP Alert*, 5(4). (Retrieved from www.npspindia.org); Uttar Pradesh has largest number of polio cases. (2000, November 4). *The Times of India*. (Retrieved from ProQuest Historical Newspapers Database, www.proquest.com)

[434] National Surveillance Project A Government of India -WHO initiative. (2001). Are we failing in UP and Bihar? *AFP Alert*, 5(4). (Retrieved from www.npspindia.org)

[435] National Surveillance Project A Government of India -WHO initiative. (2001). Are we failing in UP and Bihar? *AFP Alert*, 5(4). (Retrieved from www.npspindia.org)

The number of districts reporting poliovirus was decreasing post-2000 nationally as well as in Uttar Pradesh & Bihar. Progress was also seen in a decrease in the number of districts affected by poliovirus transmission in Uttar Pradesh. The number of polio cases reporting districts decline from 58 per cent in 1999 to 76 per cent in 2001. The polio virus transmission was shrinking nationwide and was restricted to western Uttar Pradesh. Three districts of Western Uttar Pradesh (Moradabad, Rampur, Badauan) were reporting most of the polio cases in UP (over 50 per cent). [436] Western Uttar Pradesh became a pocket of the reservoir of poliovirus.

One of the major reasons stated by GOI for the persistence of poliovirus and delay in achieving the desired success of implementation strategies in UP and Bihar was very low routine immunization coverage. Improving the routine immunization gap through multiple supplementary immunization rounds was time-consuming and this delayed the progress of UP and Bihar compared to other states. A low level of routine immunization coverage was a consistent problem in UP and Bihar compared to the rest of India. The nationwide routine immunization coverage of under-five children with three or more doses of OPV increased from 83 per cent in 1988 to 90 per cent in 2001. But for UP and Bihar, the coverage didn't exceed 80 per cent until 1999 in UP and 2000 in Bihar.[437]

The focus of the government was to cover the polio immunity gap caused by low routine immunization by implementing pre-emptive rounds, and multiple intensified supplementary immunization (SIAs).[438] There was an expectation to see the last case of polio in UP and Bihar

[436] National Surveillance Project A Government of India -WHO initiative. (2001). Are we failing in UP and Bihar? *AFP Alert*, 5(4). (Retrieved from www.npspindia.org)
[437] National Surveillance Project A Government of India -WHO initiative. (2001). Are we failing in UP and Bihar? *AFP Alert*, 5(4). (Retrieved from www.npspindia.org)
[438] National Surveillance Project A Government of India -WHO initiative. (2001). Are we failing in UP and Bihar? *AFP Alert*, 5(4). (Retrieved from www.npspindia.org)

by early 2002 and achieve the global target for certification in 2005.[439] It was planned to completely stop the transmission of poliovirus in the state of endemic reservoirs of UP and Bihar through mop-up in 2002.[440]

But in UP & Bihar consistently lagged behind in the progress towards achieving the last case of polio. In Uttar Pradesh large pool of unimmunized/under-immunized children always persisted creating the necessary immunity gap for outbreaks in UP. For the past several years UP was consistently performing low polio immunization coverage and missed a large number of children in SIAs and routine immunization. This made UP a central source of the reservoir and a global risk for polio eradication. A single state in the northern belt contributed to Uttar Pradesh 65 per cent of the global total number of cases in the year 2002.[441]

After 2001 the compliancy and providers' fatigue were setting in and enthusiasm to achieve polio eradication by 2005 was low in the country after missing the deadline of 2000. This has major consequences for overall program progress and its quality implementation. At the implementation level, the frequency of polio campaigns reduced after the completion of intensified pulse polio camping in 2000. The polio experts of India scale back its large scale NIDs and SNIDs statewide consistently from six during 1999-2000 (4 NIDs/2 SNIDs), to 4 during 2000-2001 (2 NIDs/2SNIDs) and to 3 rounds in 2001-2002 (2NIDs/1SNID).[442]

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[439] National Surveillance Project A Government of India -WHO initiative. (2001). Are we failing in UP and Bihar? *AFP Alert*, 5(4). (Retrieved from www.npspindia.org)

[440] Before the outbreak in 2002 the polio program strategy recommended was to conduct mop-ups in the state of UP and Bihar in the month of June, July and August. (National Surveillance Project A Government of India - WHO initiative. (2002). Polio Eradication Initiative: Progress & Priorities. *AFP Alert*, 6(2). (Retrieved from www.npspindia.org))

[441] Indian Expert Advisory Group (IEAG). (2003). *Seventh Meeting of the India Expert Advisory Group for Polio Eradication Sub-Group Meeting*, Lucknow, Uttar Pradesh, India, 24-25 February. (Retrieved from http://www.npspindia.org)

[442] The SNIDs primarily were covering high burden states of UP, Bihar, West Bengal and Delhi and other areas reported poliovirus transmission. The NIDs was implemented across all states as one fixed day post followed by house-to house activities in succeeding days. The SNIDs were also implemented as one fixed day post followed by extensive house- house activities in succeeding days (Indian Expert Advisory Group (IEAG). (2000). *Final Conclusions and Recommendations,' The Third Meeting of Indian Expert Advisory Group for Polio*

A decrease in the number of NIDs/SNIDs was done to save the operational costs of conducting polio campaigns.

Quality in implementing NIDs/SNIDs activity including house-to-house visits was a major contributing factor to the success of the program. It was given high priority since the start of the PPI program. Reducing the risk of intense transmission of poliovirus in high-burden states primarily depends on implementing high-quality supplementary immunization activities.[443]

But reports of deteriorating quality of NIDs/SNIDs and poor routine immunization coverage became more prominent in several districts of UP. The quality of Supplementary polio immunization activities (SIAs) was affected because of inadequate supervision, missing of houses during NIDs/SNIDs rounds (10-15 per cent of houses), insufficient participation of women and community members in vaccination teams, poor community involvement in the program.[444]

By 2000 the fear of community fatigue and the developing of social resistance[445] was coming to reality in UP's western districts of Moradabad where the intensity of the virus was high. The growing resistance was acknowledged by the program implementers. The nature of the resistance was a denial of polio vaccination campaign among certain resistance families of

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Eradication. New Delhi, India 26th May. (Retrieved from http://www.npspindia.org); Indian Expert Advisory Group (IEAG). (2001). *Recommendations of the Fourth Meetings of Experts for Polio Eradication*, New Delhi, India, 30 January. (Retrieved from http://www.npspindia.org); National Surveillance Project A Government of India -WHO initiative. (2002). Polio Eradication Initiative: Progress & Priorities. *AFP Alert*, 6(2). (Retrieved from www.npspindia.org)

[443] Indian Expert Advisory Group (IEAG). (2000). *Final Conclusions and Recommendations,' The Third Meeting of Indian Expert Advisory Group for Polio Eradication*. New Delhi, India 26th May. (Retrieved from http://www.npspindia.org); Indian Expert Advisory Group (IEAG). (2001). *Recommendations of the Fourth Meetings of Experts for Polio Eradication*, New Delhi, India, 30 January. (Retrieved from http://www.npspindia.org)

[444] National Surveillance Project A Government of India -WHO initiative. (2002). Polio Eradication Initiative: Progress & Priorities. *AFP Alert*, 6(2). (Retrieved from www.npspindia.org)

[445] Resistance to polio vaccination was not only confined to India but parts of Nigeria and Pakistan also reported similar resistance towards oral polio immunization program.

marginalized communities. In some places, a whole village boycotts the polio immunization campaigns. It spread from rumours through newspapers and some unforeseen events such as the death of a child after receiving polio drops.[446] There were many social-religious and cultural factors associated with a large number of polio cases reported from western UP.[447]

The Social Mobilization Network (SMNET) was established by UNICEF in UP in 2001. The birth of SMNET as an active channel consisting of trained people on interpersonal (IP) communication was initiated. The system of SMNET was a three-tiered structure with trained people for IP communication appointed at community, block and district levels.

At the sub-regional levels - sub-regional coordinators (SRCs) and sub-regional training coordinators (SRTCs) were placed; at the high-risk districts level – districts mobilization coordinators (DMCs) were placed; at high-risk blocks - block mobilization coordinators (BMCs) were placed and at the high-risk communities - community mobilization coordinators (CMCs) were placed. Strong behaviour change mobilization was implemented through SMNET to reduce the social resistance among the community in western UP. The purpose of these human resources was to facilitate community-level mobilization activities, particularly in high-risk areas. The functions of SMNET were designed to reach each and every house of resistant families in areas of UP tackling the resistance through interpersonal dialogue removing the myths surrounding the OPV vaccination and bridging the communication gap

[446] Arora, N.K. (1997-98). *AIIMS-INDIACLEN. Pulse Polio Immunization Program Evaluation.* Central Coordinating Team; Arora, N.K. (1998-99). *AIIMS-INDIACLEN. Pulse Polio Immunization Program Evaluation*. Central Coordinating Team; Arora, N.K. (1999-2000). *AIIMS-INDIACLEN. Pulse Polio Immunization Program Evaluation*. Central Coordinating Team.

[447]Chaturvedi et al. (2009). Deconstructing Social Resistance to Pulse Polio Campaign in Two North Indian Districts. *Indian Pediatrics,* 974(46); Ansari et al.(2013). Role of social mobilization in tackling the resistance to polio eradication program in underserved communities of Aligarh, India. *South-East Asia Journal of Public Health*, 3(2), 23-29; United Nations Children's Fund (UNICEF). (2013). *Eradicating polio getting to zero resistance*. UNICEF, Lucknow. (Retrieved from www.unicef.org)

between the program and community.[448] But despite this the community involvement in the program was low. Minority communities were consistently missing from the benefits of the program.

These implementation level operational problems, low polio immunization coverage and missing of a large number of children in SIAs and routine immunization, decrease in the number of NIDs/SNIDs, deteriorating quality of NIDs/SNIDs, rising resistance of community towards PPI campaign in western UP contributed to UP as the epicenter of 2002 outbreak. The majority of such polio cases were reported from 13 districts of western UP, especially in urban and peri-urban areas where the Muslim community is concentrated.[449] In western UP where the intensity of poliovirus was high immunization coverage performed was even low, particularly among the Muslim community.[450]

One of the major distinguishing features of the outbreak was under immunization of (20 per cent of Muslim community children in western UP during SIAs and routine immunization. Continuously missing Muslim community created immunity gaps among children, especially Muslim boys. Consequently, in 2002 outbreak in UP affected the Muslim minority community the most where more than 60 per cent of cases were reported.[451] This

[448] United Nations Children's Fund (UNICEF). (2013). *Eradicating polio getting to zero resistance*. UNICEF, Lucknow. (Retrieved from www.unicef.org); United Nations Children's Fund (UNICEF). (2003). *A critical leap to polio eradication in India*. UNICEF Publication; United Nations Children's Fund (UNICEF). (2005). *Social Mobilization Network 'Future Options' review Uttar Pradesh and Delhi, India 28 March 8 April 2005.* (Retrieved from https://iple.unicef.in/); Deloitte (2014). *Social Mobilization Network 'Future Options' Annexure to Final Report 2014.* (Retrieved from https://iple.unicef.in/)

[449] Chaturvedi et al. (2009). Deconstructing Social Resistance to Pulse Polio Campaign in Two North Indian Districts. *Indian Pediatrics,* 974(46); United Nations Children's Fund (UNICEF). (2013). *Eradicating polio getting to zero resistance*. UNICEF, Lucknow. (Retrieved from www.unicef.org)

[450] National Surveillance Project A Government of India -WHO initiative. (2002). Polio Eradication Initiative: Progress & Priorities. *AFP Alert,* 6(2). (Retrieved from www.npspindia.org)

[451] National Surveillance Project A Government of India -WHO initiative. (2002). Polio Eradication Initiative: Progress & Priorities. *AFP Alert,* 6(2). (Retrieved from www.npspindia.org)

figure was considered disproportionately high as Muslims only constitute 18.5 per cent of the total population of UP which makes it the second-largest community in the state.

4.8 Reinstating the PPI Program in 2003

Globally the year 2002 was significant for two reasons. First, the number of polio-free countries and territories reached to and the polio virus was endemic to just seven countries.[452] Second, the re-transmission of the polio virus to polio-free regions from UP overshadowed the global progress achieved so far. India was among the three countries where poliovirus was harbouring and a major source of polio infection.[453] The outbreak in 2002 was a major setback to the global polio eradication progress. After the outbreak, the global strategy was all focused on to containing the spread of the virus to polio-free countries and regions.

Globally it was highly critical for India to get back the polio program after the remarkable success achieved initially and achieve the global targets. The 2002 outbreak shed light on problems polio eradication encountered in India. Uttar Pradesh became the central focus and more emphasis was given to progress in this state. Polio eradication in UP was confronted with compliancy, provider fatigue, community fatigue and growing suspicion and anger of people towards the PPI campaign.

After the outbreak that Uttar Pradesh became the center of polio eradication program implementation in India. The polio experts' group for the very first time flew from the capital city of Delhi to the capital city of UP, Lucknow to review the polio resurgence in November

[452] Indian Expert Advisory Group (IEAG). (2003). *Seventh Meeting of the India Expert Advisory Group for Polio Eradication Sub-Group Meeting*, Lucknow, Uttar Pradesh, India, 24-25 February. (Retrieved from http://www.npspindia.org)

[453] By the end of 2002 there were three countries contributing to 99 percent of polio globally -Nigeria, Pakistan, Nigeria. In India 80 percent of polio cases were reported from six out of seventy-six states of India. (Indian Expert Advisory Group (IEAG). (2003). *Seventh Meeting of the India Expert Advisory Group for Polio Eradication Sub-Group Meeting*, Lucknow, Uttar Pradesh, India, 24-25 February. (Retrieved from http://www.npspindia.org))

of 2002.[454] Stopping poliovirus transmission within UP and neighbouring states became the core of policy guidelines in the year 2003 and in subsequent years.

There were several factors which contributed to the 2002 situation among them failed to reach all the targeted children of all populations a was prominent factor. Both reduced number of SIAs and low quality of SIAs resulted in failure to reach children and a resurgence of polio cases. The high quality of SIAs was not maintained and children were continuously missed in SIA rounds. One of the reasons considered to be an essential factor for failure to achieve high SIA coverage was lack of political engagement and lack of adequate accountability and supervision in the overall health system.[455]

Addressing operational gaps and improving the program management and performance in UP was at the highest priority in subsequent years after the outbreak of the year 2002.

The polio experts group recommended a number of activities to the government of India essential to interrupt the wild poliovirus transmission in UP and restore the program. It elicited a new set of strategies and innovations to address these challenges in UP. After the outbreak, the following year 2003 was a milestone year as it changed the focus of the program and made

[454] The sixth meeting of IEAG in 2002 was significant to review the causes of the outbreak and situation in UP and recommend strategies to GOI to restore the polio program from setbacks. Conducting IEAG meeting in challenging state of UP was also to build pressure on the implementation level providers and program managers and make them accountable. Subsequently a sub group meeting of IEAG was also conducted in February 2003 in Lucknow, Uttar Pradesh.

[455] Both UP and Bihar were endemic reservoir of wild polio virus. During the 2002 endemic transmission continued and resulted in increased in number of cases in UP. In Bihar despite evidence on endemic transmission and in increase in number of cases the quality of SIA was high enough which decreased the proportion of missed houses and increased the SIAs coverage. One of the significant differences in both the large endemic reservoir states of northern belt was stronger political support and supervision of overall health system. (National Surveillance Project A Government of India -WHO initiative. (2002). Polio Eradication Initiative: Progress & Priorities. *AFP Alert*, 6(2). (Retrieved from www.npspindia.org))

structural changes to the program implementation to reduce the aggressiveness of the polio virus in endemic districts of UP.[456]

Increasing the frequency of NIDs/SNIDs was the first policy step to restoring the PPI program in the country. The number of NIDs/SNIDs increased again from four to six per year. In the year 2003 two large-scale, NIDs and four SNIDs (targeting 60-70 million children in each round) were conducted statewide four to six weeks apart. The SNIDs rounds targeted statewide fully covered the states of UP, Bihar, Delhi and high-risk areas of West Bengal, Gujrat, and in other states of Haryana, Jharkhand and Rajasthan.[457]

Protecting the polio virus from spreading outside the Uttar Pradesh became a vital operational need. In the states of Madhya Pradesh and Uttaranchal SIA activities were implemented to partially cover the border districts to UP at risk in the 2002 outbreak.[458] In the polio-free states, large-scaled mops-up were implemented as the final activity towards interrupting the final chains of transmission in 2004.

The planning of each round of SNIDs was guided by epidemiological data to determine the extent of these rounds and to cover the additional areas required. House-to-house visit

[456] Three consecutive meetings of IEAG were conducted from February to November of 2003 to review. the progress on polio eradication. Two sub group meetings were conducted in Lucknow capital of Uttar Pradesh and in Kolkata capital of West Bengal to recommend interim measures and last meeting in year of 2003 in New Delhi capital of India.

[457] National Surveillance Project A Government of India -WHO initiative. (2002). Polio Eradication Initiative: Progress & Priorities. *AFP Alert*, 6(2). (Retrieved from www.npspindia.org); Indian Expert Advisory Group (IEAG). (2003). *Seventh Meeting of the India Expert Advisory Group for Polio Eradication Sub-Group Meeting*, Lucknow, Uttar Pradesh, India, 24-25 February. (Retrieved from http://www.npspindia.org); Indian Expert Advisory Group (IEAG). (2003). *Eight Meeting of the India Expert Advisory Group for Polio Eradication Sub-Group Meeting*, Kolkata, West Bengal, India 11-12 July. (Retrieved from http://www.npspindia.org)

[458] Indian Expert Advisory Group (IEAG). (2003). *Seventh Meeting of the India Expert Advisory Group for Polio Eradication Sub-Group Meeting*, Lucknow, Uttar Pradesh, India, 24-25 February. (Retrieved from http://www.npspindia.org); Indian Expert Advisory Group (IEAG). (2003). *Eight Meeting of the India Expert Advisory Group for Polio Eradication Sub-Group Meeting*, Kolkata, West Bengal, India 11-12 July. (Retrieved from http://www.npspindia.org)

activity after NIDs/SNIDs was made more flexible to ensure quality and adequate coverage.[459] Flexibility was assigned to all states to decide the booth and house-to-house activity. To increase maximum coverage flexibility was given to decide the number of days required after each booth activity in the region. Further participation of female members as vaccinators or as a third team member in house-to-house vaccination teams was increased.[460]

Major structural changes to the PPI program were made to increase political ownership and community participation the PPI program.

Globally it was recognized that one of the major barriers to the effective performance of the PPI program in India was political apathy and lack of supervision of the health system activities. Learning from the 2002 outbreak experience some major changes were made to the program to increase political ownership and accountability in UP from the state to the district level.[461] It was not only essential to own political leadership at the national level but also at the regional level for the progress of the PPI program.[462]

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[459] In all high burden states and other high risk areas house-to-house activity was increased to 5 days maximum (AFP Alter (2002). National Surveillance Project A government of India -WHO initiative, 6(2), March- June)

[460] National Surveillance Project A Government of India -WHO initiative. (2002). Polio Eradication Initiative: Progress & Priorities. *AFP Alert*, 6(2). (Retrieved from www.npspindia.org); Indian Expert Advisory Group (IEAG). (2003). *Seventh Meeting of the India Expert Advisory Group for Polio Eradication Sub-Group Meeting*, Lucknow, Uttar Pradesh, India, 24-25 February. (Retrieved from http://www.npspindia.org); Indian Expert Advisory Group (IEAG). (2003). *Eight Meeting of the India Expert Advisory Group for Polio Eradication Sub-Group Meeting*, Kolkata, West Bengal, India 11-12 July. (Retrieved from http://www.npspindia.org)

[461] Similar to UP in Bihar endemic transmission and increase in number of cases were reported but this does not lead to an outbreak situation in 2002. Major factor for this difference was stronger political support and adequate supervision of the health system which enabled progress of program compared to UP (National Surveillance Project A Government of India -WHO initiative. (2002). Polio Eradication Initiative: Progress & Priorities. *AFP Alert*, 6(2). (Retrieved from www.npspindia.org))

[462] In India the responsibility of providing health is accorded to the state under the constitution of the country. Giving policy directions and guidelines for implementation of PPI is responsibility of the central level government. Effective implementation of guidelines and policy directions is entirely dependent on state, district, block level government performance and community participation.

Major programmatic structural reforms were taken to improve political ownership of the PPI program in UP. A system of increasing political authority and accountability in the public health system of UP from the highest level at the state to the local level was set up.

One of the significant shifts was putting PPI program ownership in the state under the direct supervision of state Chief Ministers of State followed by State Health Minister, and State Chief Secretary. Health is a state subject in India as per the constitution of India. The responsibility of the polio eradication program administratively was always divided into three levels of governance - central, state/province, and local government. The purpose was to increase the political commitment and engagement at the highest level of governance at the state level.

The Chief Minister, Health Minister and Chief secretary were required to regularly monitor (every month) the situation of polio eradication in the state and at every district reporting wild poliovirus. The Secretary of Health and Family Welfare was made responsible to conduct briefing meetings with Chief Minister, Health Minister and Chief secretary. Particular emphasis was given to reviewing and monitoring the - epidemiological situation of polio, quality of implementation of SIA activities and monthly planned activities [463]

Similarly, the chief secretary and secretary of health and family welfare of states were made responsible to conduct monthly monitoring meetings of the program situation in each district. At the district level, the district magistrate and chief medical officers of each district were made accountable to the chief secretary and secretary of health and family welfare for

[463] National Surveillance Project A Government of India -WHO initiative. (2002). Polio Eradication Initiative: Progress & Priorities. *AFP Alert*, 6(2). (Retrieved from www.npspindia.org); Indian Expert Advisory Group (IEAG). (2003). *Seventh Meeting of the India Expert Advisory Group for Polio Eradication Sub-Group Meeting*, Lucknow, Uttar Pradesh, India, 24-25 February. (Retrieved from http://www.npspindia.org); Indian Expert Advisory Group (IEAG). (2003). *Eight Meeting of the India Expert Advisory Group for Polio Eradication Sub-Group Meeting*, Kolkata, West Bengal, India 11-12 July. (Retrieved from http://www.npspindia.org)

reporting the progress and quality of program implementation in their respective districts. In low-performing districts with sub-optimal quality of SIAs rounds chief medical officers (CMOs) and district immunization officers (DIOs) were made accountable to improve the quality.[464]

The purpose of these structural reforms was to systematically engage the political and government leaders at the highest level in the ongoing activities of PPI. Also, to establish better coordination and communication between state and central levels to monitor political commitment required at the state level.[465]

In addition, to give more focus to the polio immunization program and routine immunization in UP Additional Commissioner in each of the seventeen divisions of UP was assigned. Immunization cells (department) was established in Lucknow under the leadership of the secretary of health and family welfare. These immunization cells specifically manage polio eradication and routine immunization activities.[466]

One of the major factors for the occurrence of outbreaks was gaps in the surveillance system to accurately detect wild poliovirus transmission and gaps in quality implementation in endemic districts of UP and other states outside of UP.[467] It was clearly a lack of vigilance and

[464] Accountability was measured through use of appropriate indicators and collection of data along with regular review of indicators to maintain data quality (National Surveillance Project A Government of India -WHO initiative. (2002). Polio Eradication Initiative: Progress & Priorities. *AFP Alert*, 6(2). (Retrieved from www.npspindia.org); Indian Expert Advisory Group (IEAG). (2003). *Seventh Meeting of the India Expert Advisory Group for Polio Eradication Sub-Group Meeting*, Lucknow, Uttar Pradesh, India, 24-25 February. (Retrieved from http://www.npspindia.org))

[465] The Union Minister of Health at national level and secretary, Family Welfare and Union Minister of Health at state level were require to be briefed monthly by state Deputy Commissioner (Child Health). (Indian Expert Advisory Group (IEAG). (2003). *Eight Meeting of the India Expert Advisory Group for Polio Eradication Sub-Group Meeting,* Kolkata, West Bengal, India 11-12 July. (Retrieved from http://www.npspindia.org)

[466] Indian Expert Advisory Group (IEAG). (2003). *Seventh Meeting of the India Expert Advisory Group for Polio Eradication Sub-Group Meeting*, Lucknow, Uttar Pradesh, India, 24-25 February. (Retrieved from http://www.npspindia.org)

[467] Gaps in surveillance were identified where outbreak was a consequent of missing of genetic sequencing evidence (for over 18 months) on two separate lineages of type 3 transmission in central and eastern UP. (Indian Expert Advisory Group (IEAG). (2003). *Eight Meeting of the India Expert Advisory Group for Polio*

failure of surveillance. The speed and sensitivity of polio surveillance in central and eastern UP were weak to timely inform of increasing transmission of wild poliovirus. This allowed continued circulation of poliovirus outside UP resulting in a large outbreak in 2002. Sub-optimal surveillance became a concern and specific directives were given to restore it in high-risk areas. Strengthening of surveillance was given more emphasis after the outbreak, particularly in high-risk states and districts with deteriorating surveillance indicators.

A system of state surveillance reviews started in 2002 and was followed routinely afterwards in all large states.[468] The purpose was to periodically review gaps in the surveillance system and restore them. Surveillance data were appropriately used to target specific interventions in high-risk areas with sub-optimal surveillance indicators. More emphasis was given to the use of surveillance data for informed decision-making in program planning and execution. Special focus was given to collecting and regularly analysing AFP surveillance data to identify the poor quality of SIA and areas that are at risk of reintroduction and circulation of poliovirus.[469]

Eradication Sub-Group Meeting, Kolkata, West Bengal, India 11-12 July. (Retrieved from http://www.npspindia.org)

[468] National Surveillance Project A Government of India -WHO initiative. (2002). Polio Eradication Initiative: Progress & Priorities. *AFP Alert*, 6(2). (Retrieved from www.npspindia.org); Indian Expert Advisory Group (IEAG). (2003). *Seventh Meeting of the India Expert Advisory Group for Polio Eradication Sub-Group Meeting*, Lucknow, Uttar Pradesh, India, 24-25 February. (Retrieved from http://www.npspindia.org)

[469] Genetic sequencing data was considered good evidence to identify circulation of polio virus within and outside endemic regions and the planned focused interventions in high-risk areas. But there was an increased in workload after the 2002 outbreak at Global Specialized Laboratory in Mumbai. Consequently, there were delays in timely provision of data on genetic sequencing of polio viruses. Despite the high burden of genetic sequencing of viruses on laboratory first priority of sequencing of polioviruses isolated outside of Bihar and Uttar Pradesh was given to prevent risk of reintroduction and circulation of virus outside of these two endemic states. (National Surveillance Project A Government of India -WHO initiative. (2002). Polio Eradication Initiative: Progress & Priorities. *AFP Alert*, 6(2). (Retrieved from www.npspindia.org); Indian Expert Advisory Group (IEAG). (2003). *Seventh Meeting of the India Expert Advisory Group for Polio Eradication Sub-Group Meeting*, Lucknow, Uttar Pradesh, India, 24-25 February. (Retrieved from http://www.npspindia.org); Indian Expert Advisory Group (IEAG). (2003). *Eight Meeting of the India Expert Advisory Group for Polio Eradication Sub-Group Meeting*, Kolkata, West Bengal, India 11-12 July. (Retrieved from http://www.npspindia.org); Indian Expert Advisory Group (IEAG). (2003). *Ninth Meeting of the India Expert Advisory Group for Polio Eradication*, New Delhi, India 18-19 November. (Retrieved from http://www.npspindia.org)

More priority for state surveillance reviews was given to UP, particularly central and eastern UP after the outbreak, states outside UP at risk of poliovirus transmission and polio-free states, particularly in the south with weakening surveillance indicators.[470] State and national level monitoring of weekly active surveillance reporting was given more emphasis.[471]

The persistence of poliovirus in endemic reservoirs due to sub-optimal quality of NIDs/SNIDs, house to house and mop activities was a concern even before the 2002 outbreak. More emphasis was given to maintaining a high quality of immunization activities, particularly in high-risk regions.[472] Failure to reach all parts and each and every targeted child before 2002 was the main reason for the resurgence of poliovirus in UP and the reintroduction and circulation of poliovirus in other states. A number of steps were taken for quality improvements of SIAs in UP. The ensure quality SIAs monitoring of SIAs was given more emphasis in each cycle.

Block monitors were appointed at the block level to support micro-planning and monitoring activities.[473] More emphasis was given to collecting and reviewing monitoring data during each SIAs round for addressing operational gaps in program implementation.

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[470] Indian Expert Advisory Group (IEAG). (2003). *Eight Meeting of the India Expert Advisory Group for Polio Eradication Sub-Group Meeting*, Kolkata, West Bengal, India 11-12 July. (Retrieved from http://www.npspindia.org); Indian Expert Advisory Group (IEAG). (2003). *Ninth Meeting of the India Expert Advisory Group for Polio Eradication*, New Delhi, India 18-19 November. (Retrieved from http://www.npspindia.org)

[471] Indian Expert Advisory Group (IEAG). (2003). *Ninth Meeting of the India Expert Advisory Group for Polio Eradication*, New Delhi, India 18-19 November. (Retrieved from http://www.npspindia.org)

[472] Indian Expert Advisory Group (IEAG). (2000). *Final Conclusions and Recommendations,' The Third Meeting of Indian Expert Advisory Group for Polio Eradication*. New Delhi, India 26th May. (Retrieved from http://www.npspindia.org); Indian Expert Advisory Group (IEAG). (2001). *Recommendations of the Fourth Meetings of Experts for Polio Eradication*, New Delhi, India 30 January. (Retrieved from http://www.npspindia.org)

[473] Indian Expert Advisory Group (IEAG). (2003). Seventh Meeting of the India Expert Advisory Group for Polio Eradication Sub-Group Meeting: Lucknow, Uttar Pradesh, India 24-25 February

Monitoring data was used to identify areas with low SIA quality and in need of increased communication efforts.[474]

The role of partner agencies was increased in the high-risk states for effective management of PPI operations. Supporting state-level governments in UP partner agencies started providing appropriate technical and management support in all infected districts of UP along with other endemic states. Sharing and feedback system was initiated where monitors from partner agencies, work in coordination with central and state government to ensure information sharing of monitoring data to state management teams for improving the quality of the SIAs rounds.[475]

Two of the important components of mass vaccination campaigns are -1) sustaining community participation in the campaigns, and 2) effectively communicating to the people benefits of the program. Implementing strategies to reduce community fatigue and improve community involvement in the management of operations was crucial for the success of the program. Especially in endemic areas, specific changes were made to address the concerns of marginalized communities in the PPI program.

After repeated PPI cycles both providers and community fatigue were becoming apparent despite the use of extensive social mobilization for engaging communities. Sustaining community participation in PPI campaigns became challenging in the environment of

[474] National Surveillance Project A Government of India -WHO initiative. (2002). Polio Eradication Initiative: Progress & Priorities. *AFP Alert*, 6(2). (Retrieved from www.npspindia.org); Indian Expert Advisory Group (IEAG). (2003). *Seventh Meeting of the India Expert Advisory Group for Polio Eradication Sub-Group Meeting*, Lucknow, Uttar Pradesh, India, 24-25 February. (Retrieved from http://www.npspindia.org)

[475] National Surveillance Project A Government of India -WHO initiative. (2002). Polio Eradication Initiative: Progress & Priorities. *AFP Alert*, 6(2). (Retrieved from www.npspindia.org); Indian Expert Advisory Group (IEAG). (2003). *Seventh Meeting of the India Expert Advisory Group for Polio Eradication Sub-Group Meeting*, Lucknow, Uttar Pradesh, India, 24-25 February. (Retrieved from http://www.npspindia.org)

resentment and suspicion, particularly among marginalized communities.[476] Community participation was limited and was resulting in conflict between local priorities of integrated health services and polio eradication goals. Social mobilization strategies were exclusively top-down and designed to share the information on OPV vaccination and mobilize people. Its informed communities and directed them on what actions are required for achieving the polio eradication goal.[477] But was limited in understanding the community need and priorities resulting in a decrease in community participation over the years.

Critical to the quality of implementation of strategies in polio-endemic areas was strong advocacy and effective social mobilization. Since the start of PPI campaigns social mobilization strategies were supported by UNICEF, CORE, Rotary Club, Red cross society, the government of India and various other donors (USAID, DFID, Rotary). The communication program and social mobilization activities were partnership under the leadership of GOI and co-originated by UNICEF.

But later the communication support and strategies became more intense. CORE along with private voluntary organizations Adventist Development Relief Agency (ADRA), Project Concern International (PCI) and World Vision was part of implementing social mobilization activities in their respective PPI regions. The main highlight of core and its partnering agencies' social mobilization strategies was 'Add-on interventions'. Add-on interventions were designed to influence and change the behaviour of communities long deprived of development activities

[476] It was strongly recommended by IEAG to maintain a strong and effective program communication and social mobilization to sustain the depleting interest of community and providers particularly in polio-free states until global targets are met (National Surveillance Project A Government of India -WHO initiative. (2002). Polio Eradication Initiative: Progress & Priorities. *AFP Alert*, 6(2). (Retrieved from www.npspindia.org))

[477] Rafael, O. & Silvio, W. (2010) The Complexity of Social Mobilization in Health Communication: Top-Down and Bottom-Up Experiences in Polio Eradication. *Journal of Health Communication*, 15(1), 25-47; Taylor, E.C, Cutts, F, & Taylor, E.M. (1997). Ethical Dilemmas in Current Planning for Polio Eradication, *American Journal of Public Health*, 87(6),922-925.

through sanitation and safe water activities, and promoting family and health practices in the community.[478]

Apart from media campaigns, a range of interventions was built by this variety of partners to achieve high-level political advocacy for the program. These organizations implemented a full range of social mobilization activities to engage the community's media campaigns on TV spots, celebrity endorsements by movie actors and cricketers, interpersonal communications and the use of community leaders.[479] But the organization and funding of these communications activities were an isolated effort implemented by each partner agency under their own brand name using separate communications materials.

After the outbreak of 2002 underserved marginalized groups particularly, the Muslim community was considered to be at the highest risk of polio infection due to consistently being missed in PPI rounds and receiving fewer doses of polio vaccine.[480]

Getting support and reaching the marginalized sections of the society was difficult, particularly in Muslim communities, who were lacking access to basic healthcare and sanitary services and we're constantly demanding it.

UNICEF along with other partner organizations for many years was using the traditional approach to social mobilization[481] to bring children to the vaccination booth twice a

[478] CORE Group Polio Project (CGPP) (nd). *Combating Resistance to Polio Vaccination in Underserved Communities in Uttar Pradesh, India.* (Retrieved from https://iple.unicef.in/)

[479] United Nations Children's Fund (UNICEF). (2013). *Eradicating polio getting to zero resistance*. UNICEF, Lucknow. (Retrieved from www.unicef.org); Chaturvedi, G. (2008). *The Vital Drop: Communication for Polio Eradication in India*. Sage Publications India.

[480] In the Muslim children particularly boys the poliovirus transmission was continued and maintain. Thus, the Muslim community was seen as source of polio virus transmission and was at highest risk. (National Surveillance Project A Government of India -WHO initiative. (2002). Polio Eradication Initiative: Progress & Priorities. *AFP Alert*, 6(2). (Retrieved from www.npspindia.org); Indian Expert Advisory Group (IEAG). (2003). *Seventh Meeting of the India Expert Advisory Group for Polio Eradication Sub-Group Meeting*, Lucknow, Uttar Pradesh, India, 24-25 February. (Retrieved from http://www.npspindia.org))

year. But social mobilization strategies need a major change as the resistance, resentment, mistrust, fatigue and compliancy started setting in within the communities and impacted the PPI progress. Moving beyond the traditional approach was essential to address the various myths and misconceptions and change the attitude of people towards polio vaccination.[482] Intensifying communications strategies and innovating became more essential to sustain community engagement in the program.

The major shift in policy was necessitated developing strategies focusing on the underserved groups particularly Muslim communities to increase their participation in the program.[483] Adapting to the changed public attitudes a broad-based approach was adapted to accelerate the efforts toward changing public attitudes toward achieving polio eradication. Social resistance became the beginning of these changes impacting the communication efforts. In this phase of communication strategies evolved more as a technical strategy.[484]

Consistent with this policy shift in 2003 'underserved strategy' was initiated by UNICEF in Uttar Pradesh to increase ownership and accountability of the underserved Muslim communities for polio eradication. It was a coordinated action plan carried out in a partnership with the Government of India (GOI) and UNICEF (leadership of GOI and coordinated by UNICEF).

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[482] United Nations Children's Fund (UNICEF). (2003). *A critical leap to polio eradication in India*. UNICEF Publication; United Nations Children's Fund (UNICEF). (2013). *Eradicating polio getting to zero resistance*. UNICEF, Lucknow. (Retrieved from www.unicef.org)

[483] National Surveillance Project A Government of India -WHO initiative. (2002). Polio Eradication Initiative: Progress & Priorities. *AFP Alert*, 6(2). (Retrieved from www.npspindia.org); Indian Expert Advisory Group (IEAG). (2003). *Seventh Meeting of the India Expert Advisory Group for Polio Eradication Sub-Group Meeting*, Lucknow, Uttar Pradesh, India, 24-25 February. (Retrieved from http://www.npspindia.org)

[484] United Nations Children's Fund (UNICEF). (2003). *A critical leap to polio eradication in India*. UNICEF Publication.

The strategy was named underserved with the aim to reach out to the families in the areas of high wild poliovirus infection and poor access to basic services such as health and sanitation. The strategy was designed as an additional component of the overall communications program to increase engagement of minority and marginalized socially excluded groups which also include scheduled caste Hindus and scheduled tribes. Social mobilization activities were designed especially according to the UP tailoring to the socio-cultural needs of the Muslim communities to rectify misconceptions, ensure their participation and thereby acceptance of the polio eradication program.[485]

Under this strategy, high-risk districts and blocks were prioritized to determine for exclusive focus to increase access to basic services and increase interpersonal communication between vaccination teams and underserved communities. Implemented before the SNIDs, NIDs and mop-up rounds the purpose of social mobilization activities was designed to reach the highest risk districts to ensure adequate community participation. In the highest risk districts, more focus was given to blocks particularly urban blocks at highest risk.[486]

The strategy's major efforts were to involve universities, religious leaders, groups and local associations and individuals from underserved Muslim communities. These groups of

[485] United Nations Children's Fund (UNICEF). (2004). When Every Child counts engaging the underserved communities for polio eradication in Uttar Pradesh, India, Working paper. *United Nations Children's Fund Regional Office for South Asia.* (Retrieved from www.unicef.org); United Nations Children's Fund (UNICEF). (2013). *Eradicating polio getting to zero resistance*. UNICEF, Lucknow. (Retrieved from www.unicef.org); Chaturvedi, G. (2008). *The Vital Drop: Communication for Polio Eradication in India*. Sage Publications India.
[486] Indian Expert Advisory Group (IEAG). (2003). *Seventh Meeting of the India Expert Advisory Group for Polio Eradication Sub-Group Meeting*, Lucknow, Uttar Pradesh, India, 24-25 February. (Retrieved from http://www.npspindia.org); Indian Expert Advisory Group (IEAG). (2003). *Eight Meeting of the India Expert Advisory Group for Polio Eradication Sub-Group Meeting,* Kolkata, West Bengal, India 11-12 July. (Retrieved from http://www.npspindia.org); Indian Expert Advisory Group (IEAG). (2003). *Ninth Meeting of the India Expert Advisory Group for Polio Eradication*, New Delhi, India 18-19 November. (Retrieved from http://www.npspindia.org); United Nations Children's Fund (UNICEF). (2004). When Every Child counts engaging the underserved communities for polio eradication in Uttar Pradesh, India, Working paper. *United Nations Children's Fund Regional Office for South Asia.* (Retrieved from www.unicef.org); United Nations Children's Fund (UNICEF). (2013). *Eradicating polio getting to zero resistance*. UNICEF, Lucknow. (Retrieved from www.unicef.org); Chaturvedi, G. (2008). *The Vital Drop: Communication for Polio Eradication in India*. Sage Publications India.

people communicating about the benefits of PPI were essential to bridge the community trust gap in the program.

UNICEF engaged national and local level leaders of Muslim communities, religious leaders and organizations, influencers, and Muslim educational institutions. The engagement of influencers through collaboration with Muslim institutions and UNICEF was the key focus of this underserved strategy. Institutions such as Aligarh Muslim University, Jamia Millia Islamia, (JMI) and Jamia Hamdard. Galvanizing support from underserved communities on a massive scale these Muslim institutions was involved in planning, implementing and monitoring of polio program.

Consistent with the underserved strategy was the creation of well-functioning district and block task forces. Increasing participation of the Muslim community in district and block task forces was considered essential.[487]

Reforms were done to increase the participation of minority communities' leaders, paediatrics and medical societies associations and grassroots organization in the planning and implementation of SIA activities.[488] A special emphasis was given to involving Muslim

[487] National Surveillance Project A Government of India -WHO initiative. (2002). Polio Eradication Initiative: Progress & Priorities. *AFP Alert*, 6(2). (Retrieved from www.npspindia.org); Indian Expert Advisory Group (IEAG). (2003). *Seventh Meeting of the India Expert Advisory Group for Polio Eradication Sub-Group Meeting*, Lucknow, Uttar Pradesh, India, 24-25 February. (Retrieved from http://www.npspindia.org); United Nations Children's Fund (UNICEF). (2004). When Every Child counts engaging the underserved communities for polio eradication in Uttar Pradesh, India, Working paper. *United Nations Children's Fund Regional Office for South Asia.* (Retrieved from www.unicef.org); United Nations Children's Fund (UNICEF). (2013). *Eradicating polio getting to zero resistance*. UNICEF, Lucknow. (Retrieved from www.unicef.org); Chaturvedi, G. (2008). *The Vital Drop: Communication for Polio Eradication in India*. Sage Publications India.

[488] National Surveillance Project A Government of India -WHO initiative. (2002). Polio Eradication Initiative: Progress & Priorities. *AFP Alert*, 6(2). (Retrieved from www.npspindia.org); Indian Expert Advisory Group (IEAG). (2003). *Seventh Meeting of the India Expert Advisory Group for Polio Eradication Sub-Group Meeting*, Lucknow, Uttar Pradesh, India, 24-25 February. (Retrieved from http://www.npspindia.org)

leaders' participation in district and block task forces to address the implementation challenges of their community.[489]

Thus, district and block task forces in each district consist of members from partner organizations, and professional agencies (including the Indian Academy of Pediatrics, and the Indian Medical Association), chaired by the District Magistrate ensuring adequate participation of community leaders and leaders specifically drawn from minority communities and NGOs was mandated. The chief secretary and secretary of health and family welfare were held accountable for the creation and performance of district task forces regularly monitoring, ensuring adequate participation and engagement of minority community, functioning of DTF with regular meetings chaired by District Magistrate and engine of all participants in the meetings.[490]

Muslim influencers and institutions worked with district task forces meetings and prepared jointly planned activities with other partners. UNICEF SMNET, rotary volunteers, NGOs and government departments. These groups of people were asked to promote PPI campaigns, address the myths and suspicion of communities around polio drops and develop a positive attitude toward PPI campaigns. A range of social mobilization strategies was used by UNICEF to promote PPI campaigns such as mosque announcements, endorsements by known religious leaders/personalities interface meetings, appeals and public services announcements,

[489] National Surveillance Project A Government of India -WHO initiative. (2002). Polio Eradication Initiative: Progress & Priorities. *AFP Alert*, 6(2). (Retrieved from www.npspindia.org); Indian Expert Advisory Group (IEAG). (2003). *Seventh Meeting of the India Expert Advisory Group for Polio Eradication Sub-Group Meeting*, Lucknow, Uttar Pradesh, India, 24-25 February. (Retrieved from http://www.npspindia.org)

[490]National Surveillance Project A Government of India -WHO initiative. (2002). Polio Eradication Initiative: Progress & Priorities. *AFP Alert*, 6(2). (Retrieved from www.npspindia.org); Indian Expert Advisory Group (IEAG). (2003). *Seventh Meeting of the India Expert Advisory Group for Polio Eradication Sub-Group Meeting*, Lucknow, Uttar Pradesh, India, 24-25 February. (Retrieved from http://www.npspindia.org); Indian Expert Advisory Group (IEAG). (2003). *Eight Meeting of the India Expert Advisory Group for Polio Eradication Sub-Group Meeting*, Kolkata, West Bengal, India 11-12 July. (Retrieved from http://www.npspindia.org); Indian Expert Advisory Group (IEAG). (2003). *Ninth Meeting of the India Expert Advisory Group for Polio Eradication*, New Delhi, India 18-19 November. (Retrieved from http://www.npspindia.org)

IEC materials, local cable TV media use, banners and hoardings. The overall purpose of influencers was to facilitate the engagement of resistance families to change perceptions and opinions leading to building trust and acceptance of polio.[491]

Preventing polio transmission outside UP was equally crucial for the progress of the program. One of the major setbacks for the program after the outbreak was the occurrence of cases in states outside UP and Bihar and other high-risk states because of the exportation of poliovirus from Uttar Pradesh.

Similar to UP measures were taken in other states to strengthen and increase political and government leadership to regularly monitor the quality of implementation of SIAs, improve the quality of SIAs, increased the number of SNIDs, and flexibility to add adequate days following booth activity to ensure the highest coverage, improving the community involvement, and use of monitoring data for targeted efforts were taken in other high-risk states.[492]

The outbreak of 2002 in UP was alarming for the government of India and a major setback for the overall progress of the polio program in the country. For the Indian polio expert group, India's *unique*[493] situation demanded overall operational reforms and innovations to

[491] United Nations Children's Fund (UNICEF). (2013). *Eradicating polio getting to zero resistance*. UNICEF, Lucknow. (Retrieved from www.unicef.org); United Nations Children's Fund (UNICEF). (2004). When Every Child counts engaging the underserved communities for polio eradication in Uttar Pradesh, India, Working paper. *United Nations Children's Fund Regional Office for South Asia.* (Retrieved from www.unicef.org); Chaturvedi, G. (2008). *The Vital Drop: Communication for Polio Eradication in India*. Sage Publications India.

[492] The states were Bihar, Delhi, Gujrat, Haryana, Madhya Pradesh, Rajasthan, and West Bengal (Indian Expert Advisory Group (IEAG). (2003). *Seventh Meeting of the India Expert Advisory Group for Polio Eradication Sub-Group Meeting*, Lucknow, Uttar Pradesh, India, 24-25 February. (Retrieved from http://www.npspindia.org))

[493] Among the polio endemic countries in 2002 the IEAG considered India's situation *unique* because of three factors – 1) India has the largest number of polio cases; 2) India was the only country where transmission of polio virus was widespread to polio free areas and was re- establishing in some areas; 3) India conducted fewest number of NIDs and SNIDs since 2000 compared to other two polio endemic countries. (Indian Expert Advisory Group (IEAG). (2003). *Seventh Meeting of the India Expert Advisory Group for Polio Eradication Sub-Group Meeting*, Lucknow, Uttar Pradesh, India, 24-25 February. (Retrieved from http://www.npspindia.org)

address the uniqueness of the challenges India PPI was encountering.[494] Uttar Pradesh became a major concern because a large number of poliovirus strains were harboured in this state.

In a span of time between September 2002 and June 2003 the PPI showed incremental progress in UP after implementing the structural reforms toward improving the quality of SIAs. In Uttar Pradesh in 2003 achieved a significant improvement in the immunization status of children. The reforms taken in UP state to strengthen the political and government leadership at the highest level impacted the quality of SIAs conducted and other PPI activities. The most encouraging development was a substantial increase in the number of SIAs conducted and overall improvement in the quality of SIAs in Uttar Pradesh between 2002 and 2003.[495]

The rigorous implementation of SIAs between September 2002 to June 2003 massively impacted reducing the immunity gap at the national level and in targeted states of northern India.[496] Particularly in UP, the immunity gap was reduced to 8 per cent from 27 per cent in the targeted children aged less than 5 years.[497] Similarly, in Bihar, the other reservoir state of

[494] Government of India asked IEAG to conduct an interim meeting in the year of 2003 to review the situation and recommend interim measures in UP. The seventh meeting was conducted in February 2003 just in three months after sixth meeting in November to review the progress in UP.

[495] Indian Expert Advisory Group (IEAG). (2003). *Seventh Meeting of the India Expert Advisory Group for Polio Eradication Sub-Group Meeting,* Lucknow, Uttar Pradesh, India, 24-25 February. (Retrieved from http://www.npspindia.org); Indian Expert Advisory Group (IEAG). (2003). *Eight Meeting of the India Expert Advisory Group for Polio Eradication Sub-Group Meeting,* Kolkata, West Bengal, India 11-12 July. (Retrieved from http://www.npspindia.org)

[496] Immunity gap is based on vaccination status as defined by the percentage of non-polio AFP cases with 0-3 dose of OPV. Immunity gaps reduced in northern states where targeted SNIDs were conducted. Particularly the SIAs implemented -2NIDs and 2SNIDs in first six month of 2003 reached 58 percent of children of less than five years in India reducing the immunity gap considerably in northern Indian states (Indian Expert Advisory Group (IEAG). (2003). *Eight Meeting of the India Expert Advisory Group for Polio Eradication Sub-Group Meeting,* Kolkata, West Bengal, India 11-12 July. (Retrieved from http://www.npspindia.org); Indian Expert Advisory Group (IEAG). (2003). *Ninth Meeting of the India Expert Advisory Group for Polio Eradication*, New Delhi, India 18-19 November. (Retrieved from http://www.npspindia.org))

[497] Indian Expert Advisory Group (IEAG). (2003). *Eight Meeting of the India Expert Advisory Group for Polio Eradication Sub-Group Meeting,* Kolkata, West Bengal, India 11-12 July. (Retrieved from http://www.npspindia.org)

the northern belt of India there was a significant improvement - the immunity gap reduced to 7 per cent from 17 per cent after implementing six rounds of SIAs in September 2002.[498]

In particular, the improvement in immunization status of children ages less than five years was the result of efforts put in to improve the quality of SIAs. There was continuous and sustained improvement in the quality of implementation of SIAs in Uttar Pradesh between 2002 and 2003.[499]

There were two areas in which SIAs implementation improved consistently – 1) The SNIDs coverage levels increased in Uttar Pradesh to reach 33.01 million children in January 2003 with polio vaccination from 30.48 million in November 2002.[500] 2) Increase in coverage as a result of the increase in the quality of SIAs. In UP there were improvements in indicators of "false P" houses and conversion of "X"- marked houses. The percentage of "X"- marked houses and "False P" houses decreased substantially after the outbreak of 2002. Similarly, the socio-cultural diversity of the vaccination teams suited to the requirements of the districts improved. Participation of female vaccinators[501] and community members in the vaccination team increased.[502]

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[498] Indian Expert Advisory Group (IEAG). (2003). *Eight Meeting of the India Expert Advisory Group for Polio Eradication Sub-Group Meeting,* Kolkata, West Bengal, India 11-12 July. (Retrieved from http://www.npspindia.org)

[499] Indian Expert Advisory Group (IEAG). (2003). *Ninth Meeting of the India Expert Advisory Group for Polio Eradication*, New Delhi, India 18-19 November. (Retrieved from http://www.npspindia.org)

[500] Similarly, number of children getting vaccinated at polio booths significantly increased from 8.77 to 11.48 million between November and January (Indian Expert Advisory Group (IEAG). (2003). *Seventh Meeting of the India Expert Advisory Group for Polio Eradication Sub-Group Meeting,* Lucknow, Uttar Pradesh, India, 24-25 February. (Retrieved from http://www.npspindia.org))

[501] Emphasis was given to have a female member on every vaccination team, whether she as a vaccinator or a third member drawn from the community

[502] The false 'P' houses reporting reduced to less than 4 percent of houses and there was 44 percent increase in the conversion false X marked houses in June 2003 from 30 percent in September 2002. The number of vaccination teams with at least one female vaccinator increased to 89 percent in June 2003 from 79 percent in September 2002. Similarly, vaccination teams with one member drawn from community increased from 98 percent in June 2003 from 86 percent reported in September 2002 (Indian Expert Advisory Group (IEAG). (2003). *Seventh Meeting of the India Expert Advisory Group for Polio Eradication Sub-Group Meeting,*

One of the significant aspects of the increase in SIAs quality and coverage in UP was the increase in community participation, particularly in high-risk districts and blocks. It was the outcome of focused targeted communication and social mobilization activities implemented.[503]

Despite incremental progress in UP gaps remained and the infection caused by the outbreak of 2002 continued to spread. New polio cases and newly infected areas continued to be reported in late 2002 and in 2003 in states outside of Bihar and Uttar Pradesh.[504]

The whole focus after the outbreak was not only to strengthen the program in endemic states of UP. But also, to address the existing immunity gaps[505] in other states and high-risk areas in other states. Other high-risk states targeted for intensified SNIDs and increase in quality and high political engagement were still lagging behind in progress indicators.

Although overall SIAs quality improved with the increase in coverage levels in SNIDs targeted states reaching 97.9 million children with polio vaccine by end of 2003 June. The existing immunity gaps remained an area of great concern in other high-risk areas where only a few SIAs and with low quality were conducted.[506]

Lucknow, Uttar Pradesh, India, 24-25 February. (Retrieved from http://www.npspindia.org); Indian Expert Advisory Group (IEAG). (2003). *Eight Meeting of the India Expert Advisory Group for Polio Eradication Sub-Group Meeting,* Kolkata, West Bengal, India 11-12 July. (Retrieved from http://www.npspindia.org)

[503] Indian Expert Advisory Group (IEAG). (2003). *Ninth Meeting of the India Expert Advisory Group for Polio Eradication*, New Delhi, India 18-19 November. (Retrieved from http://www.npspindia.org)

[504] In states of Delhi, Gujrat, Haryana, Jharkhand, Madhya Pradesh, Rajasthan, West Bengal and Uttaranchal.

[505] Indian Expert Advisory Group (IEAG). (2003). *Seventh Meeting of the India Expert Advisory Group for Polio Eradication Sub-Group Meeting*, Lucknow, Uttar Pradesh, India, 24-25 February. (Retrieved from http://www.npspindia.org)

[506] The immunity gap reduced moderately in states outside of UP including Andhra Pradesh, Gujrat, Karnataka, Rajasthan and West Bengal. Despite efforts put in improve SIAs rounds in these states in 2003 by government these states were at serious risk of resurgence of polio virus transmission significantly. (Indian Expert Advisory Group (IEAG). (2003). *Eight Meeting of the India Expert Advisory Group for Polio Eradication Sub-Group Meeting,* Kolkata, West Bengal, India 11-12 July. (Retrieved from http://www.npspindia.org); Indian Expert Advisory Group (IEAG). (2003). *Ninth Meeting of the India Expert Advisory Group for Polio Eradication*, New Delhi, India 18-19 November. (Retrieved from http://www.npspindia.org)

While overall UP progress was satisfactory the variability in quality implementation reported from the ten infected states outside UP became a concern for achieving the goal of interrupting the transmission of poliovirus. These states did not implement the recommended measures to improve the gaps in immunization coverage and quality.

Lack of high political commitment and lack of uniformity in the quality of SIAs were the main areas of concern in these states. Some of the factors which were varied in states outside of UP were lack of increased political ownership where regular meetings with the chief secretary were not conducted and there were no operational district task forces.[507]

These three quality indicators of SIAs showed significant improvements in Uttar Pradesh although the practice of missing a large number of children with variability in SIAs quality continued in some districts.[508]

Despite the progress in UP, it was at a major risk compared to other endemic areas for the re-establishment of transmission. Especially of concern was the immunization status of the Muslim minority and young children (<2 years). The improvement in immunization status of children was significantly varied in central and eastern UP, particularly among Muslim children.[509]

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[507] Indian Expert Advisory Group (IEAG). (2003). *Seventh Meeting of the India Expert Advisory Group for Polio Eradication Sub-Group Meeting*, Lucknow, Uttar Pradesh, India, 24-25 February. (Retrieved from http://www.npspindia.org)

[508] Indian Expert Advisory Group (IEAG). (2003). *Seventh Meeting of the India Expert Advisory Group for Polio Eradication Sub-Group Meeting*, Lucknow, Uttar Pradesh, India, 24-25 February. (Retrieved from http://www.npspindia.org); Indian Expert Advisory Group (IEAG). (2003). *Eight Meeting of the India Expert Advisory Group for Polio Eradication Sub-Group Meeting*, Kolkata, West Bengal, India 11-12 July. (Retrieved from http://www.npspindia.org)

[509] Immunization status of young children and minority children declined in second and third quarters of 2003 in UP Because of a smaller number of SIAs conducted, higher birth rate and weakness in the routine immunization implementation in second half of the year. (Indian Expert Advisory Group (IEAG). (2003). *Ninth Meeting of the India Expert Advisory Group for Polio Eradication*, New Delhi, India 18-19 November. (Retrieved from http://www.npspindia.org)

Collection and use of monitoring data after every SIAs quality in all SNID targeted states were given more emphasis to identify districts and blocks for special attention. It facilitated timely remedial actions to address the gaps and strengthen the program particularly to improve the quality in high-risk areas identified.[510]

Uttar Pradesh's progress was encouraging compared to other states in 2003, *a state which was considered a risk for polio-free states in India and for the global progress of polio eradication efforts* because of three factors[511] 1) Increased immunization status of children, 2) Quality improvements in SIAs. Conducting quality SNIDs was critical for reducing the existing immunity gap in the targeted population, 3) Increased high level of political and government engagement and commitment to the polio eradication program. This resulted in improved quality of implementation of SIAs and a decline in the proportion of under-immunized children. Particularly increase in immunization status of Muslim children of Western UP and younger children of age less than two years of age, 4) Increased surveillance performance to accurately identify and define the high-risk areas within the state and within districts.

In the year 2003 progress was seen in some of the major reservoirs particularly UP. But at the same time, other high-risk states and polio-free states became at increased risk of poliovirus. Apart from the problem of immunity gaps in 10 high-risk states outside UP in 2003 targeted for SNIDs. In the non-endemic states where SNIDs were not conducted only mop-ups were implemented and started experiencing an increase in the immunity gap. The resurgence

[510] Indian Expert Advisory Group (IEAG). (2003). *Eight Meeting of the India Expert Advisory Group for Polio Eradication Sub-Group Meeting,* Kolkata, West Bengal, India 11-12 July. (Retrieved from http://www.npspindia.org); Indian Expert Advisory Group (IEAG). (2003). *Ninth Meeting of the India Expert Advisory Group for Polio Eradication*, New Delhi, India 18-19 November. (Retrieved from http://www.npspindia.org)

[511] Indian Expert Advisory Group (IEAG). (2003). *Eight Meeting of the India Expert Advisory Group for Polio Eradication Sub-Group Meeting,* Kolkata, West Bengal, India 11-12 July. (Retrieved from http://www.npspindia.org); Indian Expert Advisory Group (IEAG). (2003). *Ninth Meeting of the India Expert Advisory Group for Polio Eradication*, New Delhi, India 18-19 November. (Retrieved from http://www.npspindia.org)

of poliovirus transmission in polio-free southern states of Karnataka and Andhra Pradesh and in Assam became a major concern. Apart from continued transmission in West Bengal and in Assam poliovirus transmission in non-endemic states was a result of gaps in immunity in young children.[512]

The year 2003 was a year of substantial progress in the performance of the polio eradication program after the outbreak of 2002 in UP. In the states of UP and Bihar, the major polio reservoir of the country polio cases counts and under-immunized children were the lowest ever recorded from the period of July to September 2003. The high transmission season was not only restricted in the country but it was also the lowest transmission year ever recorded. [513]

This improvement in program performance was considered significant after a major setback in the 2002 outbreak in the shortest time period between 2002 to 2003.

"It is now clear that with strong government support at all levels, and effective communications and technical strategies, it is possible to reach virtually all children with OPV even in the highest risk areas during SIAs." pg. 2[514]

But these improvements were not a marker of the success of the program, particularly in endemic regions. As the extent of virus transmission in the country particularly in the high transmission season of 2003 remained uncertain.[515] Overall variation in quality among and

[512] A major outbreak occurred in these two states of Karnataka and Andhra Pradesh after two years of successful interruption of poliovirus transmission. The resurgence of poliovirus transmission in polio free states was a major marker of not just gaps in immunity but also risk of transmission from other remaining endemic reservoirs of polio. In Assam one polio case was reported in 2003 and was at higher risk of occurrence of outbreak of polio. (Indian Expert Advisory Group (IEAG). (2003). *Eight Meeting of the India Expert Advisory Group for Polio Eradication Sub-Group Meeting,* Kolkata, West Bengal, India 11-12 July. (Retrieved from http://www.npspindia.org); Indian Expert Advisory Group (IEAG). (2003). *Ninth Meeting of the India Expert Advisory Group for Polio Eradication*, New Delhi, India 18-19 November. (Retrieved from http://www.npspindia.org)

[513] Under-immunized children defined by the percentage of non-polio AFP cases with 0-3 doses of oral polio vaccine. Polio cases in the months from July-September were recorded lower than in the year of 2000.

[514] Indian Expert Advisory Group (IEAG). (2003). *Ninth Meeting of the India Expert Advisory Group for Polio Eradication*, New Delhi, India 18-19 November. (Retrieved from http://www.npspindia.org)

[515] Indian Expert Advisory Group (IEAG). (2003). *Eight Meeting of the India Expert Advisory Group for Polio Eradication Sub-Group Meeting,* Kolkata, West Bengal, India 11-12 July. (Retrieved from

within all states was a characteristic.[516] Thus, the focus of attention of IEAG was both on endemic reservoirs of UP and other high-risk states where substantial immunity gaps and quality improvement were still not achieved. [517] Sustaining the improvements gained particularly in endemic states of UP and continuous improvement was crucial for achieving the 2005 deadline of polio eradication.[518] It also required additional measures wherever needed to stop the transmission of poliovirus.[519]

Maintaining the effectiveness of interventions was equally important both in endemic and high-risk states for achieving the goal of polio eradication.[520] But the problem of funding the program activities in a timely manner particularly mobilizing sufficient funds and finding resources for communication activities was consistent. Shortage of funds particularly for complete operationalization of underserved strategy continued to be a major threat to the success of the program in UP.[521]

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http://www.npspindia.org); Indian Expert Advisory Group (IEAG). (2003). *Ninth Meeting of the India Expert Advisory Group for Polio Eradication*, New Delhi, India 18-19 November. (Retrieved from http://www.npspindia.org)

[516] Indian Expert Advisory Group (IEAG). (2003). *Seventh Meeting of the India Expert Advisory Group for Polio Eradication Sub-Group Meeting*, Lucknow, Uttar Pradesh, India, 24-25 February. (Retrieved from http://www.npspindia.org)

[517] The eight IEAG meeting was conducted in Kolkata, West Bengal due to high-risk nature of this state in 2003. The state had two major outbreaks in 2002 and early 2003. (Indian Expert Advisory Group (IEAG). (2003). *Eight Meeting of the India Expert Advisory Group for Polio Eradication Sub-Group Meeting,* Kolkata, West Bengal, India 11-12 July. (Retrieved from http://www.npspindia.org); Indian Expert Advisory Group (IEAG). (2003). *Ninth Meeting of the India Expert Advisory Group for Polio Eradication*, New Delhi, India 18-19 November. (Retrieved from http://www.npspindia.org))

[518] Indian Expert Advisory Group (IEAG). (2003). *Seventh Meeting of the India Expert Advisory Group for Polio Eradication Sub-Group Meeting*, Lucknow, Uttar Pradesh, India, 24-25 February. (Retrieved from http://www.npspindia.org); Indian Expert Advisory Group (IEAG). (2003). *Eight Meeting of the India Expert Advisory Group for Polio Eradication Sub-Group Meeting,* Kolkata, West Bengal, India 11-12 July. (Retrieved from http://www.npspindia.org)

[519] Indian Expert Advisory Group (IEAG). (2003). *Eight Meeting of the India Expert Advisory Group for Polio Eradication Sub-Group Meeting,* Kolkata, West Bengal, India 11-12 July. (Retrieved from http://www.npspindia.org)

[520] Indian Expert Advisory Group (IEAG). (2003). *Eight Meeting of the India Expert Advisory Group for Polio Eradication Sub-Group Meeting,* Kolkata, West Bengal, India 11-12 July. (Retrieved from http://www.npspindia.org)

[521] To achieve significant success in engaging community towards polio program, immediate operationalization of all communication strategies was needed included – use of TV spots, interpersonal communication and involvement of community leaders. Timely funding these activities was a major problem. To address gaps in

Despite this significant improvement in the immunization status of children in UP in 2003. The task of reaching the last eligible child in the endemic states with polio vaccination was still daunting in many aspects.

The program was consistently failing to keep up with required high routine immunization coverage and to strengthen routine immunization in Uttar Pradesh. The weakness in the routine immunization was particularly visible in the worsening of the immunization status of children in younger children aged less than two years in several states, particularly in UP.[522]

The focus of SNIDs implemented in 2003 in high-burden states particularly UP & Bihar was on improving the quality of SNIDs rounds and strengthening the routine immunization between spring and autumn rounds of SNIDs.[523]

Pulse polio program was not just an immunization program but a disease eradication program. For achieving the eradication goals strengthening the routine immunization system was essential. Before 2002 emphasis was given to intensifying routine immunization coverage in

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funding urgently for social mobilization activities IEAG requested all the partner agencies to mobilize funds under coordinated plan. (National Surveillance Project A Government of India -WHO initiative. (2002). Polio Eradication Initiative: Progress & Priorities. *AFP Alert*, 6(2). (Retrieved from www.npspindia.org); Indian Expert Advisory Group (IEAG). (2003). *Seventh Meeting of the India Expert Advisory Group for Polio Eradication Sub-Group Meeting*, Lucknow, Uttar Pradesh, India, 24-25 February. (Retrieved from http://www.npspindia.org); Indian Expert Advisory Group (IEAG). (2003). *Eight Meeting of the India Expert Advisory Group for Polio Eradication Sub-Group Meeting*, Kolkata, West Bengal, India 11-12 July. (Retrieved from http://www.npspindia.org); Indian Expert Advisory Group (IEAG). (2003). *Ninth Meeting of the India Expert Advisory Group for Polio Eradication*, New Delhi, India 18-19 November. (Retrieved from http://www.npspindia.org)

[522] National Surveillance Project A Government of India -WHO initiative. (2002). Polio Eradication Initiative: Progress & Priorities. *AFP Alert*, 6(2). (Retrieved from www.npspindia.org); Indian Expert Advisory Group (IEAG). (2003). *Seventh Meeting of the India Expert Advisory Group for Polio Eradication Sub-Group Meeting*, Lucknow, Uttar Pradesh, India, 24-25 February. (Retrieved from http://www.npspindia.org); Indian Expert Advisory Group (IEAG). (2003). *Ninth Meeting of the India Expert Advisory Group for Polio Eradication*, New Delhi, India 18-19 November. (Retrieved from http://www.npspindia.org)

[523] Indian Expert Advisory Group (IEAG). (2003). *Seventh Meeting of the India Expert Advisory Group for Polio Eradication Sub-Group Meeting*, Lucknow, Uttar Pradesh, India, 24-25 February. (Retrieved from http://www.npspindia.org)

states of high burden areas through distinct efforts and adequate investments.[524] The focus of IEAG and polio eradication program was only on planning and implementing SNIDs which was a separate activity compared to routine immunization.[525] Thus, routine immunization got neglected in a considerable way and became a consistent problem in the coming years of PPI implementation. It was only in 2002 that routine immunization was more stressed and separate strategies were recommended to states to strengthen routine immunization and maintain high coverage.[526]

Strengthening routine immunization became a main focal area for interventions in high-risk areas. Regular review and recommendation on strategies for strengthening routine immunization strategy, particularly in UP became the core in the IEAG subsequent meetings after 2002. After the 2002 outbreak to strengthen the routine immunization in Uttar Pradesh & Bihar the state governments based on polio experts' group' recommendations put in efforts to prepare an operational joint plan of action for both polio eradication and strengthening of routine immunization. Regular review in each polio experts' groups meetings was to discuss the implementation of routine immunization plans and achievements made in the coverage in all polio-endemic regions. Progress reports were asked from polio-endemic states including the definition of the role of partners, appropriate technical support and advice at the state level and defined times lines and milestones for improving routine immunization. Data on numeric

[524] Indian Expert Advisory Group (IEAG). (2000). *Final Conclusions and Recommendations,' The Third Meeting of Indian Expert Advisory Group for Polio Eradication*. New Delhi, India 26th May. (Retrieved from http://www.npspindia.org)

[525] There was major concern on reported stock outs of measles and DTP (Diphtheria, Tetanus, Pertussis vaccines in some states)

[526] Reviewing progress in implementation of strategies for improving routine immunization was added as an objective for discussion in IEAG meetings in 2002 and in subsequent meetings (National Surveillance Project A Government of India -WHO initiative. (2002). Polio Eradication Initiative: Progress & Priorities. *AFP Alert*, 6(2). (Retrieved from www.npspindia.org); Indian Expert Advisory Group (IEAG). (2003). *Seventh Meeting of the India Expert Advisory Group for Polio Eradication Sub-Group Meeting*, Lucknow, Uttar Pradesh, India, 24-25 February. (Retrieved from http://www.npspindia.org))

indicators were also asked from polio-endemic states on services provided in routine immunization.[527]

Particular focus was given to strengthening the routine immunization in urban areas in state action plans. These were also areas which were at higher risk of resurgence or continued transmission of poliovirus.[528]

In the endemic states particularly UP a typical case of polio was defined as a Muslim boy child aged less than two years in 2003. Because a large number of polio cases were reported from young children, particularly from UP Muslim communities whose population density is very high compared to other regions.

By the end of 2002 highest number of polio cases (84 per cent) were reported among children less than two years of age.[529] In the year 2003 after the outbreak, the number still reported more than 75 per cent of cases. It was clearly a failure to vaccinate young children. Particularly the children of Muslim minority communities where still in 2003 large number of polio cases were occurring (77 per cent).[530]

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[527] National Surveillance Project A Government of India -WHO initiative. (2002). Polio Eradication Initiative: Progress & Priorities. *AFP Alert*, 6(2). (Retrieved from www.npspindia.org); Indian Expert Advisory Group (IEAG). (2003). *Seventh Meeting of the India Expert Advisory Group for Polio Eradication Sub-Group Meeting*, Lucknow, Uttar Pradesh, India, 24-25 February. (Retrieved from http://www.npspindia.org); Indian Expert Advisory Group (IEAG). (2003). *Eight Meeting of the India Expert Advisory Group for Polio Eradication Sub-Group Meeting*, Kolkata, West Bengal, India 11-12 July. (Retrieved from http://www.npspindia.org); Indian Expert Advisory Group (IEAG). (2003). *Ninth Meeting of the India Expert Advisory Group for Polio Eradication*, New Delhi, India 18-19 November. (Retrieved from http://www.npspindia.org)

[528] Indian Expert Advisory Group (IEAG). (2003). *Ninth Meeting of the India Expert Advisory Group for Polio Eradication*, New Delhi, India 18-19 November. (Retrieved from http://www.npspindia.org)

[529] Indian Expert Advisory Group (IEAG). (2003). *Seventh Meeting of the India Expert Advisory Group for Polio Eradication Sub-Group Meeting*, Lucknow, Uttar Pradesh, India, 24-25 February. (Retrieved from http://www.npspindia.org)

[530] Indian Expert Advisory Group (IEAG). (2003). *Eight Meeting of the India Expert Advisory Group for Polio Eradication Sub-Group Meeting*, Kolkata, West Bengal, India 11-12 July. (Retrieved from http://www.npspindia.org)

4.9 Opportunity to End Polio Transmission - *Final Push*

On January 15, 2004 ministers of health from the endemic states (Nigeria, Pakistan, Niger, Afghanistan, Egypt, and India) got together at WHO Headquarters in Geneva to discuss the current challenges of the polio eradication program. Minsters of health signed the Geneva Declaration for the eradication of Poliomyelitis. Through this declaration, the health ministers made a global commitment to end poliovirus transmission in their countries by 2004. The WHO gave a call in 2004 – '*now more than ever: stop polio forever'*.[531] The year 2004 was seen as the final year to interrupt the poliovirus transmission globally where endemic countries were made responsible to free the world from polio. In consistence with the global call to accelerate the polio eradication efforts in endemic countries the minsters committed to the implementation of intensified polio immunization activities, strong government engagement and oversight at the national level of all polio eradication activities; facilitating direct oversight of polio program at state/provincial level through establishing state committees; ensuring all children are reached in every polio immunization campaign round and ensure full participation of all minority groups and underserved populations.[532]

By the end of 2003, the progress achieved in polio program performance was promising enough to call an end to poliovirus transmission in India in the year 2004. Particularly encouraging was the situation in large reservoirs of UP and Bihar. This was the success achieved in the shortest possible timeline of over a year ever in the program's history. Encouraged by the progress and commitment made at the Geneva Declaration, the ministry of

[531] World Health Organization. (2004). *Polio eradication: now more than ever, stop polio forever*. (Retrieved from www.who.int)
[532] World Health Organization. (2004). *Geneva Declaration for the eradication of Poliomyelitis.* Geneva, Switzerland. (Retrieved from www.who.int)

Health and Family Welfare set 2004 as the target year to end the transmission of wild poliovirus in the country.[533]

The year of 2004 was decided to completely interrupt the wild poliovirus transmission in India and strategies were planned accordingly.[534] Interrupting the transmission of poliovirus was the main objective in 2004 and to ensure this many aggressive and accelerated strategies were conducted. A major commitment to end polio was made by all the international and national partner agencies, the Union government of India and state governments.

"This requires sustained leadership on the part of the Government of India and all State governments, and renewed commitment and aggressive action at all levels" pg.3[535]

There were three components considered critical for achieving the goal to end polio transmission in 2004[536] -1) End the transmission in long-established endemic reservoirs of UP and Bihar in the country particularly western UP, 2) End the transmission in high-risk areas outside of UP completely and sustained the national level population immunity to not allow new high-risk areas to emerge, 3) The most essential component required was to achieve and maintain a stronger government leadership at all levels.

The strategy developed for the first six months of 2004 was to end the poliovirus transmission. The focus was to implement the highest quality SIAs in such a manner to reduce the continued

[533] Indian Expert Advisory Group (IEAG). (2003). *Ninth Meeting of the India Expert Advisory Group for Polio Eradication*, New Delhi, India 18-19 November. (Retrieved from http://www.npspindia.org)
[534] Indian Expert Advisory Group (IEAG). (2003). *Ninth Meeting of the India Expert Advisory Group for Polio Eradication*, New Delhi, India 18-19 November. (Retrieved from http://www.npspindia.org)
[535]Indian Expert Advisory Group (IEAG). (2003). *Ninth Meeting of the India Expert Advisory Group for Polio Eradication*, New Delhi, India 18-19 November. (Retrieved from http://www.npspindia.org)

[536] Indian Expert Advisory Group (IEAG). (2003). *Ninth Meeting of the India Expert Advisory Group for Polio Eradication*, New Delhi, India 18-19 November. (Retrieved from http://www.npspindia.org)

transmission in endemic and high-risk states. So that mop-ups could be implemented to end the final chains of polio transmission starting in the second half of 2004.[537]

Subsequently, measures were taken to improve and maintain the overall population-level immunity in the country. Conducting NIDs was the main priority to achieve the highest level of population immunity nationwide. The number of NIDs implemented was increased in 2004 to five rounds and intensified SNIDs particularly targeted the states of high-risk states.[538] In non-endemic states where SNIDs were not implemented focus was more given to implementing high-quality NIDs and routine immunization to address the immunity gaps identified.[539]

Government leadership at the highest level was the most essential component to stop the transmission of poliovirus in 2004. It not only required continued leadership of the polio eradication program from states. But also, stronger oversight at the highest government level, engagement from the Prime Minister of India and President.

Government supervision and engagement at the highest level was increased through providing a monthly written briefing on the status of polio eradication activities to the Prime Minister's office, organizing meeting between Prime Minister and Chief Minister and Chief Secretaries in endemic and high-risk areas, and direct public appeals to citizens by Prime

[537]Indian Expert Advisory Group (IEAG). (2003). *Ninth Meeting of the India Expert Advisory Group for Polio Eradication*, New Delhi, India 18-19 November. (Retrieved from http://www.npspindia.org)

[538] Large scale SIAs of six rounds were implemented in 2004. The five rounds of NIDs were conducted in January, February, April and from September to November six weeks apart. One round of SNIDs was implemented in May. The SNIDs targeted states of Uttar Pradesh, Bihar, West Bengal, Delhi, Haryana, Jharkhand, Gujarat, Rajasthan, Madhya Pradesh and Assam (Indian Expert Advisory Group (IEAG). (2003). *Ninth Meeting of the India Expert Advisory Group for Polio Eradication*, New Delhi, India 18-19 November. (Retrieved from http://www.npspindia.org))

[539] Indian Expert Advisory Group (IEAG). (2003). *Ninth Meeting of the India Expert Advisory Group for Polio Eradication*, New Delhi, India 18-19 November. (Retrieved from http://www.npspindia.org); Indian Expert Advisory Group (IEAG). (2004). *Eleventh Meeting of the India Expert Advisory Group for Polio Eradication*, Delhi, India 10-11 June. (Retrieved from http://www.npspindia.org)

Minister and President to provide national support to the polio eradication program. In all endemic, high-risk states and states reporting poliovirus in 2003, the focus continued to get political and government engagement from Chief Ministers/Chief Secretary and State Minister of Health.[540]

Reaching the target of interruption of poliovirus in 2004 it was essential to improve the overall quality of SIAs in all the components. Some of the existing challenges to ensure the highest quality of SIAs implemented at the end of 2003 were in high-risk areas were– the continued missing of houses in endemic districts of western UP and other high-risk states, weakness in supervision, gaps in the training of vaccinators, and in implementation of coordinated monitoring activities.[541]

A large migration of people, mostly seasonal occur every year from endemic regions of UP and Bihar. Most people in villages of rural areas migrated to seek employment in other regions and states along with their families including children. This nature of migration became a serious problem in ensuring complete coverage of targeted children. Children of such transient families which migrated missed the tOPV doses both in routine immunization and SIAs. Consequently, the polio program was missing a large number of transient children (including both unvaccinated and under-vaccinated) who migrated to other states.

Such children became a potential risk for continued polio transmission in the country. Focused increased on the transient population, urban slums and populations and nomadic

[540]Indian Expert Advisory Group (IEAG). (2003). *Ninth Meeting of the India Expert Advisory Group for Polio Eradication*, New Delhi, India 18-19 November. (Retrieved from http://www.npspindia.org); Indian Expert Advisory Group (IEAG). (2004). *Tenth Meeting of the India Expert Advisory Group for Polio Eradication*, Delhi, India 26-27 March. (Retrieved from http://www.npspindia.org); Indian Expert Advisory Group (IEAG). (2004). *Eleventh Meeting of the India Expert Advisory Group for Polio Eradication*, Delhi, India 10-11 June. (Retrieved from http://www.npspindia.org)

[541] Indian Expert Advisory Group (IEAG). (2003). *Ninth Meeting of the India Expert Advisory Group for Polio Eradication*, New Delhi, India 18-19 November. (Retrieved from http://www.npspindia.org)

populations to ensure complete coverage in both routine immunization and SIAs, particularly in UP and Bihar.[542]

Ensuring complete coverage in SIAs rounds was crucial to eliminating the polio virus, particularly in endemic states of UP and Bihar. Thus, catching the migration streams became an important component of polio program implementation to ensure complete coverage. Consequently, the transit vaccination strategy was launched in 2005. Efforts were made to develop the strategy to reach the transient population in all the districts. Tracking the transient areas and eligible children in each district and providing them with polio drops was a major component of this activity. In each SIAs round mobile immunization teams at areas of transit points and assemblage points were placed to ensure maximum coverage of transient children such as at railway stations, bus stands, highways, markets, and at religious and community festival sites. [543]

Despite the overall promising situation particularly in UP. It was critical for the program implementers to be vigilant and consistently identify the high-risk districts and blocks performing low for implementing corrective interventions. Ensuring the overall high quality of SIAs was critical. In all the high-risk states reporting transmission of wild poliovirus by the end of 2003 measures were taken to increase the monitoring of the program at the highest political level in states. Process of providing written reports of each SNIDs round specifying the districts with sub-optimal performance, written briefing report on the overall status of the

[542] Indian Expert Advisory Group (IEAG). (2004). *Eleventh Meeting of the India Expert Advisory Group for Polio Eradication*, Delhi, India 10-11 June. (Retrieved from http://www.npspindia.org); Indian Expert Advisory Group (IEAG). (2004). *The Twelfth Meeting of the India Expert Advisory Group for Polio Eradication*, Delhi, India 2-3 December. (Retrieved from http://www.npspindia.org)

[543] Microplanning and adequate supervision and training was major component for the success of this activity. Areas within each district where transient population reside and are found were identified and mobile immunization teams were deployed to ensure complete coverage of transient population. (Indian Expert Advisory Group (IEAG). (2004). *The Twelfth Meeting of the India Expert Advisory Group for Polio Eradication*, Delhi, India 2-3 December. (Retrieved from http://www.npspindia.org); United Nations Children's Fund (UNICEF). (2003). *A critical leap to polio eradication in India*. UNICEF Publication)

program in the state and written plan of action of all four SIAs round[544] were mandated for the first six months of 2004.[545]

Both operational and communication strategies were focused on quality improvement to reach each and every child in 2004. The year 2004 was a year where tremendous efforts were put into the program to implement the multiple SIAs multiple rounds, improving the quality and enhancing surveillance sensitivity from the national to village level. Aggressive and accelerated efforts were used to stop the polio transmission in 2003 and continued in 2004 consequently reducing the number of polio cases. Three program areas where significant improvement was achieved in 2004 were – 1) the program surveillance sensitivity improved particularly in UP and Bihar, and 2) High-level immunity was achieved in non-reservoirs of poliovirus outside endemic reservoirs areas. [546]

Overall genetic diversity of the type 1 poliovirus was recorded less in 2004 compared to 2003. But the poliovirus type 1 transmission was more compared to poliovirus type 3 in the country. Poliovirus type 1 transmission in both UP and Bihar was more intense than type 3 as the majority of cases reported were of type 1.[547] The western UP became the largest source of

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[544] The written plan of action on four SIAs rounds was mandated only from three high-risk states -UP, Bihar, and West Bengal (Indian Expert Advisory Group (IEAG). (2003). *Ninth Meeting of the India Expert Advisory Group for Polio Eradication*, New Delhi, India 18-19 November. (Retrieved from http://www.npspindia.org); Indian Expert Advisory Group (IEAG). (2004). *Tenth Meeting of the India Expert Advisory Group for Polio Eradication*, Delhi, India 26-27 March. (Retrieved from http://www.npspindia.org)

[545] These reports were to be submitted to chief secretary at state level by secretary of health and family welfare within two weeks of SIAs rounds. (Indian Expert Advisory Group (IEAG). (2003). *Ninth Meeting of the India Expert Advisory Group for Polio Eradication*, New Delhi, India 18-19 November. (Retrieved from http://www.npspindia.org); Indian Expert Advisory Group (IEAG). (2004). *Tenth Meeting of the India Expert Advisory Group for Polio Eradication*, Delhi, India 26-27 March. (Retrieved from http://www.npspindia.org); Indian Expert Advisory Group (IEAG). (2004). *Eleventh Meeting of the India Expert Advisory Group for Polio Eradication*, Delhi, India 10-11 June. (Retrieved from http://www.npspindia.org))

[546] Indian Expert Advisory Group (IEAG). (2004). *Eleventh Meeting of the India Expert Advisory Group for Polio Eradication*, Delhi, India 10-11 June. (Retrieved from http://www.npspindia.org); Indian Expert Advisory Group (IEAG). (2004). *The Twelfth Meeting of the India Expert Advisory Group for Polio Eradication*, Delhi, India 2-3 December. (Retrieved from http://www.npspindia.org)

[547] There were three major cluster of type 1 WPV reported in 2004 and only one cluster of type 3 WPV. The type 3 WPV cases were limited to only Bihar and UP with majority of cases originating from UP. (Indian Expert

all polio cases originating in other states of India. The largest cluster of type 1 wild poliovirus (WPV) in 2004 was maintained by western UP, poliovirus originating from this cluster distinctly had several different chains of transmission.[548]

The progress achieved by the PPI program in 2003 was sustained and improved by the end of the year 2004 in UP particularly western UP along with Bihar. Polio cases detected remained lowest compared to past years in India throughout the year 2004.[549]

The significant progress achieved in Uttar Pradesh from 2002 to 2003 as a result of varied program measures which were implemented. Five major areas of action were increasing government ownership of the program, increasing in number of SIAs to six rounds, improving the overall quality of SIAs and improving the performance of the surveillance system and improvement in community mobilization strategies targeting the high-risk population. But the districts in western UP remained at higher risk with the continued transmission of poliovirus along with the emergence of other high-risk areas. By the end of the 2003 year because of continued transmission in two western districts in UP (Aligarh and Badaun) were critically seen at high risk for exporting poliovirus to other areas in UP, other states within India and globally.[550] The western UP along with Bihar became a major risk and threat to the overall

Advisory Group (IEAG). (2004). *The Twelfth Meeting of the India Expert Advisory Group for Polio Eradication*, Delhi, India 2-3 December. (Retrieved from http://www.npspindia.org))

[548] Other states included in this cluster were Delhi, Haryana and Uttaranchal, cases from eastern part of central Bihar, one case from West Bengal and Maharashtra and Mumbai. In Mumbai there was continued transmission of type 1 WPV from December of 2003 resulting in two cases in Mumbai and Thane in 2004. (Indian Expert Advisory Group (IEAG). (2004). *The Twelfth Meeting of the India Expert Advisory Group for Polio Eradication*, Delhi, India 2-3 December. (Retrieved from http://www.npspindia.org))

[549] Indian Expert Advisory Group (IEAG). (2004). *Tenth Meeting of the India Expert Advisory Group for Polio Eradication*, Delhi, India 26-27 March. (Retrieved from http://www.npspindia.org); Indian Expert Advisory Group (IEAG). (2004). *Eleventh Meeting of the India Expert Advisory Group for Polio Eradication*, Delhi, India 10-11 June. (Retrieved from http://www.npspindia.org); Indian Expert Advisory Group (IEAG). (2004). *The Twelfth Meeting of the India Expert Advisory Group for Polio Eradication*, Delhi, India 2-3 December. (Retrieved from http://www.npspindia.org)

[550] Indian Expert Advisory Group (IEAG). (2003). *Ninth Meeting of the India Expert Advisory Group for Polio Eradication*, New Delhi, India 18-19 November. (Retrieved from http://www.npspindia.org)

global success of the eradication program in 2004 and in subsequent years. Overcoming these continuous risk areas changes in program strategies and more strenuous efforts were the focus of the government at the national and state level in India.

In both UP and Bihar, the reservoirs of poliovirus in the country reported cases in the year 2004. The majority (more than 90 per cent) of polio cases were circumscribed to western UP and central Bihar, reduced to a small cluster of districts.[551]

Government commitment to finish the job of ending polio in India was overwhelming increased after 2002.[552] From May 2004 onwards the prime objective of the program was to treat any wild poliovirus cases detected in the country as a *public health emergency*.[553]

Despite this program's performance in the year, 2004 was considered "extraordinary progress towards polio eradication"[554]. But as anticipated by the end of the year 2004 the final chains of transmission were not interrupted throughout the country including in endemic states of northern regions, the goal was still distant. The program continued with critical focus given to high-priority districts of UP, particularly in western UP, Bihar and Maharashtra. The problem was limited in these three states, particularly to high-priority districts reporting

[551] Other states reported few cases were Maharashtra, Delhi, Haryana, West Bengal, Andhra Pradesh, Karnataka, Tamil Nadu, Uttaranchal. (Indian Expert Advisory Group (IEAG). (2004). *The Twelfth Meeting of the India Expert Advisory Group for Polio Eradication*, Delhi, India 2-3 December. (Retrieved from http://www.npspindia.org))

[552] Even after the change in Union government in 2004 due to periodic general election there was no decrease in commitment and oversight required for polio program. The 11th IEAG meeting in 2004 after change in Union government was attended by Union Minister of Health and Family Welfare and Union secretary for Family Welfare.

[553] The meaning of declaring any polio case detected as public health emergency was strong oversight and engagement of governance from prime minster level/Union health minster to state chief minister/chief secretary/ district commissioner/district magistrate level where a case of polio was reported. It involves to identify the causes of polio cases occurrence and rigorous measures to maintain the immunity of targeted children. Along with day-to-day monitoring and implementation of the program. (Indian Expert Advisory Group (IEAG). (2004). *Tenth Meeting of the India Expert Advisory Group for Polio Eradication*, Delhi, India 26-27 March. (Retrieved from http://www.npspindia.org); Indian Expert Advisory Group (IEAG). (2004). *Eleventh Meeting of the India Expert Advisory Group for Polio Eradication*, Delhi, India 10-11 June. (Retrieved from http://www.npspindia.org)

[554] Indian Expert Advisory Group (IEAG). (2004). *The Twelfth Meeting of the India Expert Advisory Group for Polio Eradication*, Delhi, India 2-3 December. (Retrieved from http://www.npspindia.org)

consistent gaps in implementing high-quality SIAs essential for interrupting the polio transmission.[555] The program was extended to 2005 to stop the transmission by improving SIAs performance in these areas in the first few months of the year.

But failure to interrupt the WPV transmission at the end of 2004 and the continued focus of the program in the largest polio reservoir areas of UP and Bihar, particularly western UP increased doubts and suspicion about the program strategies used in these areas.

4.10 Accelerate the Polio Efforts to End Polio

Building on the increased performance of the program achieved in 2003, the program performance was hugely increased by the end of 2004 to call it a 'historic opportunity",[556] on the verge to stop polio in the country. It was a great opportunity in the history of the program to stop polio because both geographically and genetically the poliovirus transmission was restricted between 2003 and 2004. All the cases reported outside the endemic reservoirs of UP and Bihar since 2004 were caused by the importation of poliovirus from UP and Bihar.[557]

But despite tremendous efforts and scaling up of activities required to stop the final chains of poliovirus transmission from 2003 to 2004. The targeted strategy of achieving zero poliovirus transmission in each SIAs rounds to stop polio was still far away in the remaining reservoirs of the country (UP and Bihar).

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[555] The high priority district was 13 in UP and 16 districts in Bihar. In Maharashtra the city of Mumbai and Thane were at high priority (Indian Expert Advisory Group (IEAG). (2004). *The Twelfth Meeting of the India Expert Advisory Group for Polio Eradication*, Delhi, India 2-3 December. (Retrieved from http://www.npspindia.org))

[556] Indian Expert Advisory Group (IEAG). (2004). *The Twelfth Meeting of the India Expert Advisory Group for Polio Eradication*, Delhi, India 2-3 December. (Retrieved from http://www.npspindia.org)

[557] World Health Organization. (2009). Independent Evaluation of major Barriers to Interrupting Poliovirus. Transmission in India. (Retrieved from www.polioeradication.org)

There were several reasons for the low quality of SIAs in these two reservoir areas of UP and Bihar. During the critical period of 2004, the program was lacking any sustained leadership. The strong government commitment was crucial for achieving the goal of interrupting poliovirus and was achieved from the national to state level despite the periodic national elections in India in 2004. But high-level oversight and consistent engagement required by the Union government represented by the union ministry of health was lacking within the program. Gaps in serious engagement and lack of ownership of the program in high-priority districts of UP and Bihar were also visible among state and district level governments.[558]

The "final push" given in the program for interrupting the poliovirus by the end of 2004 required additional rounds of high-quality SIAs. This increased the program budget considerably within the context where the program in India was already facing a funding shortage.[559] Irregularities in timely cash flow to the program increased the overall cost of program planning, vaccine procurement price and donor coordination. Lack of timely availability had major implications for the program increasing the risks.[560]

"The major problem with polio in India was high cost, new vaccines procurement every time, wastage of vaccine, with every polio round repetition. And despite this there were cases of polio and outbreaks. The repetition of polio cases was risk to children."[561]

[558] Indian Expert Advisory Group (IEAG). (2004). *Tenth Meeting of the India Expert Advisory Group for Polio Eradication*, Delhi, India 26-27 March. (Retrieved from http://www.npspindia.org)
[559] There were discrepancies in funding between government of India and its national and international partners. The government of India made commitment to provide 100 million dollars for polio eradication to address shortage of funds but funds were not timely release which increased the overall cost of program. To compensate shortage of funds on exceptional basis UNICEF sanctioned a bridging loan to facilitate procurement of OPV. (Indian Expert Advisory Group (IEAG). (2004). *Tenth Meeting of the India Expert Advisory Group for Polio Eradication*, Delhi, India 26-27 March. (Retrieved from http://www.npspindia.org)
[560] Indian Expert Advisory Group (IEAG). (2004). *Tenth Meeting of the India Expert Advisory Group for Polio Eradication*, Delhi, India 26-27 March. (Retrieved from http://www.npspindia.org)
[561] Interview

Increasing fatigue and continuous deterioration in morale and confidence in both workers and the community in program activities was becoming a major risk factor within the program. To maintain the motivation of both community and workers in the polio program need to include comprehensive communication strategies as part of overall communication strategies was considered necessary, particularly in high-priority reservoir areas.[562]

Strengthening routine immunization (RI) was one of the core strategies for achieving poliovirus interruption severely neglected for several years. The performance of overall routine immunization in achieving the child immunization goals in India particularly in the state of UP was low. A large number of children missed out on RI services. The full immunization schedule including BCG, three doses of DPT and Polio along with Measles was given only to 46 per cent of children. About 20 per cent of children didn't receive a single vaccination dose under RI. Strengthening of immunization programs was critical particularly in urban areas, with Muslim, illiterate parents and the population living in plains and unreachable population groups.[563] There were several gaps in the overall routine immunization structure.

By the year 2004 major efforts were put in to improve RI by national and state governments to identify and address state-specific problems in RI services in districts. Multi years plan for strengthening RI and improving routine coverage was further developed and implemented in several states. [564]

[562] Indian Expert Advisory Group (IEAG). (2004). *Eleventh Meeting of the India Expert Advisory Group for Polio Eradication,* Delhi, India 10-11 June. (Retrieved from http://www.npspindia.org); Indian Expert Advisory Group (IEAG). (2004). *The Twelfth Meeting of the India Expert Advisory Group for Polio Eradication*, Delhi, India 2-3 December. (Retrieved from http://www.npspindia.org)

[563] Suresh, S. (2007). *Immunization Coverage in India working paper series No. E/283/2007*. Institute of Economic Growth and University Enclave.

But despite these efforts put into RI, the country was still suffering from a timely supply of RI vaccines at the state level and stock out of vaccines. It was a major core concern to effectively run the RI program.[565]

The PPI program's responsibilities were also influenced by other activities performed by the health personnel, particularly health workers responsible for routine immunization.

"Within the health staff, the personnel did have other official responsibilities to perform but the focus was mainly on PPI program before, during and after National Immunization Days leaving only a few months for them to concentrate on their designated tasks other than PPI program. Particularly for health workers responsible for routine immunization there seemed to be some "pressurizing" influence on their performance as far as their primary responsibility was concerned."[566]

The overall quality of SIAs and consequently immunization status of children increased in 2003 and continued in 2004 in many areas.[567] But technically achieving high-quality planned SIA was still distant although the speed of detection increased the risk of failure to stop transmission.

Improvement in immunization quality and access to children in each round of SIAs continued to achieve steady improvement since 2003 and in 2004 especially in UP and Bihar and other high-priority states. Improvement in access to children as a result of expansion and rigorous implementation of social mobilization and communication activities, strong operational activities and technical inputs, especially in the underserved population, particularly Muslim populations in Western UP.[568]

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[565] Indian Expert Advisory Group (IEAG). (2004). *Tenth Meeting of the India Expert Advisory Group for Polio Eradication*, Delhi, India 26-27 March. (Retrieved from http://www.npspindia.org); Indian Expert Advisory Group (IEAG). (2004). *Eleventh Meeting of the India Expert Advisory Group for Polio Eradication*, Delhi, India 10-11 June. (Retrieved from http://www.npspindia.org)

[566] Interview

[567] Indian Expert Advisory Group (IEAG). (2004). *The Twelfth Meeting of the India Expert Advisory Group for Polio Eradication*, Delhi, India 2-3 December. (Retrieved from http://www.npspindia.org)

[568] Indian Expert Advisory Group (IEAG). (2004). *Tenth Meeting of the India Expert Advisory Group for Polio Eradication*, Delhi, India 26-27 March. (Retrieved from http://www.npspindia.org); Indian Expert Advisory Group (IEAG). (2004). *Eleventh Meeting of the India Expert Advisory Group for Polio Eradication*, Delhi, India

Particular efforts were made in social mobilization and communication activities to reach the underserved population, particularly Muslim populations in Western UP. Despite improvement in the quality of immunization and access in western UP. The impact of these efforts in closing the immunity gap was still not sufficient in western UP. Immunization status of Muslim children was still lower compared to other general populations.[569] There was a constant strive within the program to search for additional strategies (both operational and communications) to improve access to children in high-priority districts, particularly in underserved communities of western UP.[570]

Because of the sporadic cases reported from outside UP and Bihar in large share, stringent efforts and overall quality of the program activities have to be maintained to achieve the reach the final goal of eradicating polio even after 2004. Failure to reach the targeted goal of interrupting the polio virus in 2004 and extending it to 2005 had both programmatic and financial implications. 1) the overall national polio immunity has to be maintained through high-quality SIAs to prevent the resurgence of poliovirus; 2) geographically limited reservoirs of poliovirus were at constant risk of importation of virus across India and in neighbouring countries 3) the extension of the program has an impact on sustaining motivation of program providers and community; 4) increases the overall program budget in the context where the program was already struggling for funds from different sources to fill funding gaps.

10-11 June. (Retrieved from http://www.npspindia.org); Indian Expert Advisory Group (IEAG). (2004). *The Twelfth Meeting of the India Expert Advisory Group for Polio Eradication*, Delhi, India 2-3 December. (Retrieved from http://www.npspindia.org)

[569] In 2004 around 65 percent of WPV cases in India were reported from western UP of which 80 percent of cases occurred in Muslim children of underserved population. (Indian Expert Advisory Group (IEAG). (2004). *The Twelfth Meeting of the India Expert Advisory Group for Polio Eradication*, Delhi, India 2-3 December. (Retrieved from http://www.npspindia.org)

[570] Indian Expert Advisory Group (IEAG). (2004). *The Twelfth Meeting of the India Expert Advisory Group for Polio Eradication*, Delhi, India 2-3 December. (Retrieved from http://www.npspindia.org)

Beginning in 2005 the government was hopeful and determined to achieve the goal of poliovirus interruption in the first few months of this year. The overall objective was to maintain the momentum of the program performance in the country gained by the end of 2004 and continue improvement in high-priority districts of western UP, Bihar and Mumbai.[571]

The focus of the program and its limited resources were diverted all to high-priority districts in UP, Bihar and greater Mumbai/Thane. The SIAs aimed at stopping the transmission completely in reservoir areas of these three districts. For the rest of the country, the priority was maintaining a high level of immunity and responding to any wild poliovirus as a public health emergency through rapid and high-quality mop-ups.

One of the major program improvements in the country in the first half of 2005 was achieving high-quality of AFP surveillance and uniformity of basic quality surveillance indicators. In the past the AFP surveillance system in the country missed polio transmission and ensuring uniformity in the quality of surveillance indicators across districts was a major challenge. The planning process of AFP surveillance activities at the district level was a detailed and elaborated effort with the aim of not missing any AFP case.

"AFP Surveillance was done with meticulous planning and designation of specific health units for reporting. Both government hospitals, private facilities and even quacks were designated as VHP (Very High Priority), High Priority (HP) and low priorities depending on the case load and the likelihood of children coming with any case of acute flaccid paralysis. The VHP had to be visited every week by a field monitor or the SMO. We had detailed mapping of all these facilities and planning was done weekly and monthly so that no high priority facilities were missed. Our contacts were displayed in all these facilities and they would call the unit in case of any AFP cases. This was again crosschecked and verified during visits by going through the OPD register and other entries. The district Immunization Officer and SMO took the lead in AFP surveillance. Case investigation of reported cases was done by any medical officer, SMO or DIO. The SMO would again verify cases at the community level or at the household. Government medical officers who investigated cases were given a small amount of Rs 200 by WHO-NPSP. Trainings around AFP surveillance was supported by WHO-NPSP time to time at the district head quarter or at the blocks. During monthly plans, facilities which were found to be missing cases (not reporting)

[571] In these three areas by the end of 2004 the poliovirus transmission continued in low transmission season. Other areas at risk for continuing transmission of virus were central and eastern UP and west Bengal (Kolkata and surrounding areas of the city) (Indian Expert Advisory Group (IEAG). (2004). *The Twelfth Meeting of the India Expert Advisory Group for Polio Eradication*, Delhi, India 2-3 December. (Retrieved from http://www.npspindia.org))

were focused and more visits were done to these by field monitors or the SMO. These facilities were classified as high priority and repeated visits were done till they were compliant (Not missing any AFP Case)" [572]

So operationally high sensitivity of surveillance was given more focus against the specificity of detecting AFP cases.[573] Surveillance data were more reliable and of high-quality operating at a very high level of sensitivity in detecting the AFP cases. The focus on sensitivity eliminates the risk of missing poliovirus transmission. For interrupting the poliovirus transmission, it helped in detecting the transmission in districts previously missed but as a consequence surveillance data was reporting very high rates of AFP cases, particularly in UP and Bihar.[574]

By the end of 2005 poliovirus transmission in the high season consistently declined to an extremely low level and was genetically restricted to western UP and Bihar. This was seen as a major achievement historically compared to high transmission periods in previous years of the program.

"The very low transmission detected in the peak transmission season of 2005, despite the significant improvement in surveillance sensitivity, indicates that wild poliovirus is now having great deal of difficult in surviving in India." pg.2[575]

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[572] Interview

[573] The increase in sensitivity of surveillance increases in number of reporting cases which were not AFP cases thus compromising the specificity of detecting the AFP case as per the classification of AFP definition in the country.

[574] Along with increase in performance of surveillance laboratory network in India continued to perform at high quality within timeline, in the context of continually increasing workload. (Indian Expert Advisory Group (IEAG). (2005). *The Thirteenth Meeting of the India Expert Advisory Group for Polio Eradication*, New Delhi, India 3-4 May. (Retrieved from http://www.npspindia.org); Indian Expert Advisory Group (IEAG). (2005). *The Fourteenth Meeting of the India Expert Advisory Group for Polio Eradication*, New Delhi, India 5-6 December. (Retrieved from http://www.npspindia.org))

[575] Indian Expert Advisory Group (IEAG). (2005). *The Fourteenth Meeting of the India Expert Advisory Group for Polio Eradication*, New Delhi, India 5-6 December. (Retrieved from http://www.npspindia.org)

An extremely low level of transmission as a result of accelerated efforts to end poliovirus in the country. Both high quality of surveillance and improvement in strong government ownership both at the national, state and district level in endemic states were contributing factors to this achievement.[576] Moreover, a major contributing factor was a focused effort made to reach each and every child in high-risk districts of UP and Bihar through the expansion and implementation of transit[577] and underserved strategies[578].

By the end of 2005, the continued program improvement resulted in increasing the immunization status of children against polio to a very high level than before achieved in high-risk districts of UP and Bihar. Especially in reaching children of age less than two years and of the Muslim minority in western UP.

Both operational and communication measures facilitated more access to children with OPV in 2005. This resulted in better immunization.

"Children in India in 2005 are better immunized against polio than ever before" pg.3[579]

Much of the program performance was significantly achieved in the first half of 2005 as per the target goal decided by the end of 2004. The overall progress of performance in

[576]In UP the government oversight was sustained but after the Geneva Ministers meeting in January 2005 there was increase in high level engagement of Bihar and Maharashtra government. (Indian Expert Advisory Group (IEAG). (2005). *The Thirteenth Meeting of the India Expert Advisory Group for Polio Eradication*, New Delhi, India 3-4 May. (Retrieved from http://www.npspindia.org)).

[577] The expansion of transit points under transit strategy led to accessing more moving population in the three endemic states covering approximately 5 million children by transit teams alone during the April NID round of 2005. Moreover, a special railway strategy was initiated to capture more moving population in the routes of their migration (Indian Expert Advisory Group (IEAG). (2005). *The Thirteenth Meeting of the India Expert Advisory Group for Polio Eradication*, New Delhi, India 3-4 May. (Retrieved from http://www.npspindia.org))

[578] Underserved strategy was able to reach more underserved Muslim population in high-risk districts of western UP although not all districts were fully covered by it in 2005. But there was an increase in number of the teams having female Muslim vaccinator and local influencer.(Indian Expert Advisory Group (IEAG). (2005). *The Thirteenth Meeting of the India Expert Advisory Group for Polio Eradication*, New Delhi, India 3-4 May. (Retrieved from http://www.npspindia.org))

[579] Indian Expert Advisory Group (IEAG). (2005). *The Thirteenth Meeting of the India Expert Advisory Group for Polio Eradication*, New Delhi, India 3-4 May. (Retrieved from http://www.npspindia.org)

surveillance and high coverage and immunization of children in high-priority districts built the hopes and confidence to achieve the goal of ending the poliovirus transmission by the end of 2005. But the by the end of 2005 the transmission of poliovirus continued in the endemic reservoirs of the country.

In the years 2004 and early 2005, the program made significant progress in performance historically not achieved since the start of the program in 1995. Apart from improving program indicators and using innovation in accessing more children, the long-term process of strengthening routine immunization (RI) services was progressing in the country.[580] Particularly focus was given to improving access and coverage of infants to RI services in the endemic regions. Significant efforts were made by the government in 2005 for rehabilitation of the cold chain system; ensuring adequate funding to the state government by union government; independent monitoring of immunization services in UP and Bihar.[581]

Low program performance remained a major concern in some of the high-risk districts of western UP but especially in Bihar. By the end of 2004 and 2005 Bihar became the greatest risk to polio eradication program in the country than UP, particularly western UP. The continuous deterioration of the quality of SIAs and ongoing transmission in Bihar was exporting poliovirus to other states in India (Mumbai, Punjab, Jharkhand and UP) and to neighbouring countries (Nepal). The quality of the program deteriorated over the years since

[580] The RI was given a major restructuring and restoring work was done by the national technical advisory group for immunization (NITAGI). A national policy and state specific plans were developed for RI for improving the immunization services.

[581] Indian Expert Advisory Group (IEAG). (2005). *The Thirteenth Meeting of the India Expert Advisory Group for Polio Eradication*, New Delhi, India 3-4 May. (Retrieved from http://www.npspindia.org)

2002 both surveillance indicators and immunization status of children decline. The polio program's main focus was to get back to previous high-level quality in the state. [582]

Apart from the sub-optimal quality of implementation and major operational gaps doubts were raised in the country on the polio eradication strategies used in the country, especially in the endemic reservoir of UP. During the initial period of the program doubts about the efficacy of the trivalent oral polio vaccine (tOPV) and the effectiveness of eradication strategies were raised for UP and Bihar by polio experts and media.

But such doubts were denied by the government due to the decline in the number of cases together with the decline in the number of polio-infected districts. The dramatically declining numbers of cases and polio-infected districts in UP were major evidence by GOI of the high level of potency of OPV and the effectiveness of the eradication strategies implemented in the country. Government strategies used in UP and Bihar were working as well as in other countries around the world.[583] For the WHO also there was no contentions and doubt on the strategies used for polio eradication. It was always the sub-optimal quality of implementation in a polio-endemic country which failed to give the higher impact of strategies as seen in other countries.[584]

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[582] In both UP and Bihar under state development planes more emphasis was given to focus on high-risk district within states for improvement. More high-risk areas were covered with SMNET and communication activities under underserved strategy in western UP Efforts were made to expand both SMNET and communication activities in Bihar to capture high risk areas. (Indian Expert Advisory Group (IEAG). (2004). *The Twelfth Meeting of the India Expert Advisory Group for Polio Eradication*, Delhi, India 2-3 December. (Retrieved from http://www.npspindia.org); Indian Expert Advisory Group (IEAG). (2005). *The Thirteenth Meeting of the India Expert Advisory Group for Polio Eradication*, New Delhi, India 3-4 May. (Retrieved from http://www.npspindia.org); Indian Expert Advisory Group (IEAG). (2005). *The Fourteenth Meeting of the India Expert Advisory Group for Polio Eradication*, New Delhi, India 5-6 December. (Retrieved from http://www.npspindia.org))

[583] National Surveillance Project A Government of India -WHO initiative. (2001). Are we failing in UP and Bihar? *AFP Alert*, 5(4). (Retrieved from www.npspindia.org).

[584] National Surveillance Project A Government of India -WHO initiative. (2001). Technical Consultative Group on Vaccine-Preventable Diseases in South East Asia Region. *AFP Alert*, 5(6). (Retrieved from www.npspindia.org).

IEAG repeatedly assured us the country that the polio eradication strategies used are effective and there are only operational and technical gaps which need to be focused on.

"The IEAG reaffirms that the major strategies being followed are correct, appropriate, and effective."pg.2[585]

The timely and adequate availability of adequate doses of OPV vaccine including adequate doses of other vaccines used in routine immunization was always a major operational gap in the program implementation. Furthermore, the low potency[586] of polio vaccination was becoming a major concern in the country, a major contributing factor to low immunity in targeted children. The problem of low potency of polio vaccination and vaccine failure was widely studied and discussed in India by eminent scientists before the start of the program. It was already widely studied in India that tOPV was not working in the Indian context contrary to international claims of 100 per cent antibody after three doses. Trivalent oral polio vaccine failure was detected in India in the 1960s where the immune response was seen as very different for tOPV in India where after three doses of tOPV there was clinical vaccine failure resulting in infection. It was observed low antibody response to type 3 and type 1 virus in the Indian context compared to the good antibody response to type 2 components.[587]

Major policy steps were taken to increase the number of SIAs campaigns in endemic regions to track and immunize each child. In the endemic region since 2004 annual pulse polio vaccination campaigns were conducted 10 times in each year. The endemic region of UP and Bihar achieved 90 per cent immunization coverage and children were given more than four

[585] Indian Expert Advisory Group (IEAG). (2004). *The Twelfth Meeting of the India Expert Advisory Group for Polio Eradication*, Delhi, India 2-3 December. (Retrieved from http://www.npspindia.org)

[586] Low potency of vaccine causes high incidence of polio cases primarily in vaccinated children.

[587] John, T.J. (2016). India's Research Contributions Towards Polio Eradication (1965-2015). *Indian Journal of Pediatrics*,53, (1-6).

doses of tOPV. Despite these efforts, the two states were reporting a high incidence of polio cases.

After the 2002 outbreak, the Ministry of Health in India to ensure vaccine quality gave directives to use only OPV vaccines which are pre-qualified (guaranteed potency) in both polio eradication programs and in the routine immunization programs.[588]

But the questioning of the low potency of tOPV continued after missing the 2000 deadline. Although it was not strong enough to bring any policy change to the program. During the years 2004 and 2005 major contentions with strategies at global and regional levels were seen where it was said that global strategies do not work.[589] The overall potency of tOPV vaccination was questioned strongly against the polio infection in children targeted.[590]

There were serious epidemiological limitations of tOPV in endemic regions of India. It was already known that in the tropical and developing countries the potency of tOPV was low in developing immunity against the poliovirus infection.[591] The problem of sub-potent polio vaccine administration became visible with reporting of a large number of polio cases in vaccinated children in the endemic region of north India. Response of tOPV in boosting immunity against the polio virus was low creating suitable conditions for the high incidence of

[588] Indian Expert Advisory Group (IEAG). (2003). *Eight Meeting of the India Expert Advisory Group for Polio Eradication Sub-Group Meeting,* Kolkata, West Bengal, India 11-12 July. (Retrieved from http://www.npspindia.org)

[589] Sathyamala, C., Mittal, O., Dasgupta, R., and Priya, R. (2005). Polio Eradication Initiative in India: Deconstructing the GPEI. *International Journal of Health Services*, 35(2), 361-83

[590] Paul, Y. (2005). Polio eradication programme: Some Ethical Issues. *Indian Journal of Medical Ethics*, II(4); Paul, Y, & Dawson, A. (2005). Some Ethical Issues Arising from Polio Eradication Programmes in India. *Bioethics*, 19(4), 393-406; Sathyamala, C., Mittal, O., Dasgupta, R., and Priya, R. (2005). Polio Eradication Initiative in India: Deconstructing the GPEI. *International Journal of Health Services*, 35(2), 361-83

[591] Melnick. J.L. (1978). Advantages and disadvantages of killed and live poliomyelitis vaccines, *Bull World Health Organization*, 56(1): 21-38s

polio cases and frequent outbreaks.[592] The variant nature of OPV in different contextual environments in India raised doubts about the safety and effectiveness of tOPV and on achieving eradication goals among the world researchers and public health experts.[593]

There was growing concern about a large proportion of polio cases in highly vaccinated children. This high number of polio cases and frequent outbreaks in northern India raised doubts about the potency of the vaccine used. This demanded the need to study the reasons and strategies to tackle the growing problem immediately for the success of the polio eradication program. From the mid-2000s the need for research to answer several questions on the potency of tOPV was needed.

The GOI and NPSP commissioned a pilot study to answer the questions about the low potency of tOPV and the use of mOPV in the endemic state of India. The research confirmed that tOPV which eliminated polio in developed countries showed poor efficacy in different epidemiological and environmental conditions in endemic countries.[594] The polio vaccine efficacy suffered from epidemiological, environmental, and genetic factors in northern parts of Uttar Pradesh and Bihar states India.[595]

The piloted research confirmed the high efficacy of mOPV-1 in India's endemic regions. The mOPV oral polio vaccine was three times more effective in conditions of the high

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[592] Paul, Y. & Priya (2004). Polio eradication in India: Some Observations. *Vaccine*, 22,4144–4148.

[593] Paul, Y. & Priya (2004). Polio eradication in India: Some Observations. *Vaccine*, 22,4144–4148.
Paul, Y, & Dawson, A. (2005). Some Ethical Issues Arising from Polio Eradication Programmes in India. *Bioethics*, 19(4), 393-406; Sathyamala, C., Mittal, O., Dasgupta, R., and Priya, R. (2005). Polio Eradication Initiative in India: Deconstructing the GPEI. *International Journal of Health Services*, 35(2), 361-83.

[594] Grassly, N.C., Fraser, C., Wenger, J., Deshpande, J.M., Sutter, R.W., Heymann, D.L., et al. (2006). New strategies for the elimination of polio from India. *Science.*314, 1150-3.

[595] Grassly, N.C., Fraser, C., Wenger, J., Deshpande, J.M., Sutter, R.W., Heymann, D.L., et al. (2006). New strategies for the elimination of polio from India. *Science.*314, 1150-3; Grassly et al. (2007). Protective efficacy of a monovalent oral type 1 poliovirus vaccine: a case-control study. *Lancet*, 369, 1356-62.

prevalence of diarrhoea and other infections compared to trivalent OPV.[596] At the global level diarrhoea and the presence of other enteric infections was major factor in the low potency of the polio vaccine in India.[597]

Consistent with the research findings a major vaccination policy change was taken by GOI in 2005. It was one of the innovations introduced at the final stages of eradication initiatives to improve the immune response among children. This change in the OPV vaccine was in accordance with the recommendations of the global advisory committee on polio to enhance the impact of SIAs rounds in endemic areas.

India licensed the use of trivalent OPV (tOPV) to monovalent OPV (mOPV) type 1 and (mOPV) type 3 vaccine in 2005, particularly in high-risk areas of UP and Bihar and Mumbai/Thane/Raigad. The plan developed was the exclusive use of (mOPV) type 1 in SIAs implemented in high-risk areas (as type 1 poliovirus was highly transmitting poliovirus in high-risk areas). The extensive use of (mOPV) type 1 began in SIAs in April 2005 in high-risk areas with persistent high transmission of type 1 poliovirus and in areas where type 1 poliovirus transmission is detected. Additional of mOPV1 was an innovation to enhance the impact of supplementary immunization activities. [598]

But despite introducing a new vaccine, mOPV1 in endemic regions with UP and Bihar there was a slow decline in the incidence of polio cases reported. In most of the states in India in 2005 were reporting polio-free poliovirus transmission in endemic states of UP and Bihar

[596] Grassly, N.C., Fraser, C., Wenger, J., Deshpande, J.M., Sutter, R.W., Heymann, D.L., et al. (2006). New strategies for the elimination of polio from India. *Science*.314, 1150-3; Grassly et al. (2007). Protective efficacy of a monovalent oral type 1 poliovirus vaccine: a case-control study. *Lancet*, 369, 1356-62

[598] Indian Expert Advisory Group (IEAG). (2004). *The Twelfth Meeting of the India Expert Advisory Group for Polio Eradication*, Delhi, India 2-3 December. (Retrieved from http://www.npspindia.org); Indian Expert Advisory Group (IEAG). (2005). *The Thirteenth Meeting of the India Expert Advisory Group for Polio Eradication*, New Delhi, India 3-4 May. (Retrieved from http://www.npspindia.org)

was not stopped. The country was not ready to turn the page on polio eradication. The global deadline to interrupt the poliovirus transmission was shifted to 2007 from 2005.

Simultaneously with the development of polio immunization campaigns a major contextual change in the organization of health care services took place in India. Major health reform in the health services system of India was taken with the launch of the National Rural Health Mission in 2005. The reform was a major health welfare initiative of the new government to reduce health disparities between rural and urban regions. The purpose of the mission was to place a fully functional health care system for the people in the remote villages in rural India. Each fully functional health centre for the surrounding area was staffed with at least one doctor, a midwife, a nurse, and a family and sanitary inspector for the area. One of the major core components of the extension of rural services was the recruitment of community health workers ASHA (Accredited Social Health Activist). The ASHA workers drawn from the community were responsible to promote healthcare services within the community and facilitate their access to healthcare centers. These community health workers were a bridge between health facilities and communities. Placing health facilities and ASHA workers in remote areas which never had access to health services before facilitated building the community trust. This change in delivery and organization of health care services helped in the further implementation of PPI particularly with the involvement of ASHA workers in vaccination teams.

4.11 The Second Outbreak in UP – Failure of Immune Response in UP

Hopeful and confident the program entered the next year, the year of 2006 with the major objective to maximize on the program performance made in 2005 and to knock out the poliovirus from the country. The major strategy was to increase the program's effectiveness in

low transmission season to reduce the strength of the poliovirus in peak transmission season in high-risk districts of UP and Bihar.

But the program was again struck with a continuous increase in the number of polio cases in high-risk districts of western UP in the first half of 2006. This led to an outbreak by the middle of the year. This was the third consecutive outbreak since the program started in 1995. In the year 2006 in total reported 641 cases of which 623 cases were of type 1 poliovirus and 18 cases of type 3 poliovirus. The majority of cases were reported from western UP and Bihar and from 14 other states in India.[599]

There was an overall declining trend in the number of polio cases registered in the country since the start of the program in 1995. As the efforts were strengthened to effectively improve and implement PPI campaigns in the country, an outbreak in 2006 in UP and Bihar derailed the progress made so far.

Although the 2006 outbreak was less intense in terms of size compared to previous years of the resurgence in 2002 and in 1998.[600] The reduced intensity of the outbreak of 2006 was regarded as the overall higher population immunity.[601] The epidemiology of poliovirus transmission by the end of 2005 pointed toward all the possibilities to interrupt the transmission in 2006. Despite the overall good performance of the program, there were some high-risk areas continuing the circulation of the polio virus in the country. It was clear that the overall

[599] In UP around 81 percent of cases reported (519 polio cases), in Bihar 9 percent (57 polio cases), and 10 percent (65 polio cases) in 14 other states and union territories (which include states of Haryana, Uttaranchal, Punjab, Delhi, Maharashtra, Gujrat, Madhya Pradesh, Assam, Chandigarh, Himanchal Pradesh, Jharkhand, Rajasthan, West Bengal and Jammu & Kashmir). (National Surveillance Project A Government of India -WHO initiative. (2007). Progress in Polio Eradication. *AFP Alter*,11(1). (Retrieved from www.npspindia.org))

[600] A total of 1600 polio cases were registered in 2002 compared to 641 in 2006

[601] National Surveillance Project A Government of India -WHO initiative. (2007). Progress in Polio Eradication. *AFP Alter*,11(1). (Retrieved from www.npspindia.org)

improved quality performance of the program within the states of UP and Bihar was masking the deteriorating quality of the program in some areas.

Since 2000 endemic reservoir areas of western UP and Bihar were causing all viral spread and increase in polio cases in India. The pattern of occurrence of the outbreak and spread of poliovirus was similar, reoccurring every four years centered in historical endemic reservoir areas in India.

By the end of 2005, the total number of cases was significantly low and the geographical spread of the circulating virus was limited to western UP and Bihar. Epidemiologically there were positive pieces of evidence for the interruption of circulating poliovirus in 2006. In 2006 western UP and Bihar were again the states central to the occurrence of a polio outbreak in the history of the polio program in India. Its endemic reservoir areas were responsible for the spreading of poliovirus within states and across other states.

In UP the 2006 outbreak occurred in the districts of Moradabad[602] and JP Nagar in western UP and spread outward covering much of the area of western UP, spreading to central and eastern UP and to neighbouring states. In Bihar outbreak originated in endemic districts in the north-central of Bihar, spread to the south covering many southern districts in Bihar and further spread to the west covering neighbouring eastern UP infecting many districts.[603]

[602] Number of type 3 poliovirus cases increased since 2005 and all were centered in 2006 in few districts in western UP.

[603] National Surveillance Project A Government of India -WHO initiative. (2007). Progress in Polio Eradication. *AFP Alter*,11(1). (Retrieved from www.npspindia.org).

The 2006 outbreak exposed some of the pre-existing operational, environmental and sociological gaps in the polio program implementation[604] But in Bihar, the spread of the outbreak was much less intense with a limited increase in polio cases than in UP. It was acknowledged by IEAG that

"It is clearly much more difficult to stop wild poliovirus transmission in certain areas of India, particularly western UP, than it is in most other areas of the world."pg.3[605]

The endemicity of clusters in northern India, together with repetitive outbreaks and slow progress of the overall PPI program despite consistent efforts was frustrating for the global community. It also had overall implications on the overall cost of the program as well.

"Globally the frustration of polio program in India was the slow process of government and despite lot of commitment every time efforts were made there were new cases and outbreaks, the failure to make program work. Medical response and large amount of investment was been wastage because of repeated cases and efforts to make vaccine reach each and every child again and gain. This was leading to high cost of program and investment, again and again vaccine procurement, health and community workers mobilization in short repetition of activities of program."[606]

So why does western UP continue to be central to polio outbreaks in India? Overall, in the state of UP, the poliovirus circulation was reducing and the quality of SIAs was improving.[607] The geographical spread of poliovirus in the country was limited to only a few

[604] National Surveillance Project A Government of India -WHO initiative. (2006). Current Polio Situation. *AFP Alter Alert,*10(2). (Retrieved from www.npspindia.org); National Surveillance Project A Government of India -WHO initiative. (2007). Progress in Polio Eradication. *AFP Alter*,11(1). (Retrieved from www.npspindia.org)

[605] Indian Expert Advisory Group (IEAG). (2006). *The Fifteenth Meeting of the India Expert Advisory Group for Polio Eradication*, Delhi, India 4-5 May. (Retrieved from http://www.npspindia.org)

[606] Interview

[607] Only five chains of wild polio virus type 1 remained in 2005 compared to 8 chains in circulating in UP in 2004. Similarly in Bihar only 4 chains of wild polio virus type 1 circulating in 2005 compared to 5 in 2004. (Indian Expert Advisory Group (IEAG). (2006). *The Fifteenth Meeting of the India Expert Advisory Group for Polio Eradication*, Delhi, India 4-5 May. (Retrieved from http://www.npspindia.org); National Surveillance Project A Government of India -WHO initiative. (2006). Current Polio Situation. *AFP Alter Alert,*10(2). (Retrieved from www.npspindia.org); National Surveillance Project A Government of India -WHO initiative. (2007). Progress in Polio Eradication. *AFP Alter*,11(1). (Retrieved from www.npspindia.org)

districts in western UP and Bihar in 2005. There were some high-risk districts within western UP continuing the circulation of poliovirus as the majority of cases in 2006.

It was the emergence of a few western districts of UP as the endemic reservoir of WPV. Poliovirus exportation from these endemic pockets of clusters of districts in a repeated manner to other parts of India and to other countries.

In western UP it was Moradabad and its sub-regions which became risk factors for the overall success of the program. Moradabad district in 1998 was reporting a very high number of polio cases.[608] In the 2006 outbreak, there was a marked increase in cases in Moradabad districts and in its sub-regions. Moradabad was the only district which reported both type 1 and type 3 polio cases in 2006. All 18 polio cases of type 3 were reported in 2006 were from this district, a marked increase from 4 cases of type 3 reported in 2005.[609] There were various programmatic and contextual socio-cultural factors contributing to the deterioration of the quality of the polio program in Moradabad and its sub-regions.

"Implementation of PPI program did suffer some hiccups in Uttar Pradesh, to some extent due to socio-religious reasons. But some important reasons for endemicity of a few clusters in UP was attributed to lacunae in program implementation, barriers in social mobilization due to poor campaigning, not reaching difficult to reach population and failure to negate rumours and false propaganda."[610]

Operationally it was a failure to reach targeted children in high-priority areas in each and every SIA round in late 2005 and early 2006. The overall quality of SIAs implemented in

[608] Arora, N.K. (2000). *Progress towards polio eradication: Service delivery, socio-cultural and communization barriers in pulse polio immunization in high burden zone in India.* Clinical Epidemiology Unit, All India Institute of Medical Sciences (AIIMS).

[609] Indian Expert Advisory Group (IEAG). (2006). *The Fifteenth Meeting of the India Expert Advisory Group for Polio Eradication*, Delhi, India 4-5 May. (Retrieved from http://www.npspindia.org); National Surveillance Project A Government of India -WHO initiative. (2006). Current Polio Situation. *AFP Alter Alert,*10(2). (Retrieved from www.npspindia.org); National Surveillance Project A Government of India -WHO initiative. (2007). Progress in Polio Eradication. *AFP Alter,*11(1). (Retrieved from www.npspindia.org)

[610] Interview

the region was uneven and deteriorated preceding the outbreak, particularly in Moradabad. A significant percentage of houses were missed consistently in SIAs, more than 10 per cent. This increased the risk of wild poliovirus circulation creating a pool of susceptible children to poliovirus.[611]

"Biggest policy issues were or challenge was the vaccine card was not updated to verify all children given vaccine. It depends on recall of mothers by vaccine givers to give children vaccines. Survey results were unclear. Lack of evidence as biggest policy issues."[612]

The majority of the increase in the number of poliovirus cases in 2006 was reported among children less than 3 years of age and from the underserved Muslim community in UP.[613] Both decreased coverage of children and an increase in percentages of missed houses allowed an increase in the number of susceptible children over a period of time resulting in the outbreak.[614]

For the success of the program in stopping transmission in western UP high-risk districts, it was necessary for the program to ensure around 95 per cent of eligible children are reached and vaccinated in every SIAs round to achieve the desired level of immunity in the

[611] Other regions in western UP where overall quality of SIAs continue to be a problem were - Badaun, Aligarh, JP Nagar, Hathras, Bulandshahar, and Muzaffarnagar (National Surveillance Project A Government of India - WHO initiative. (2006). Current Polio Situation. *AFP Alter Alert*,10(2). (Retrieved from www.npspindia.org); Indian Expert Advisory Group (IEAG). (2006). *The Fifteenth Meeting of the India Expert Advisory Group for Polio Eradication*, Delhi, India 4-5 May. (Retrieved from http://www.npspindia.org); National Surveillance Project A Government of India -WHO initiative. (2007). Progress in Polio Eradication. *AFP Alter*,11(1). (Retrieved from www.npspindia.org).

[612] Interview

[613] In UP 72 percent of cases occurred in less than 3 years of age children compared to 69 percent of cases at country level. Majority of cases in UP occurred (61 percent) in undeserved in Muslim community compared to 56 percent of cases at national level (National Surveillance Project A Government of India -WHO initiative. (2007). Progress in Polio Eradication. *AFP Alter*,11(1). (Retrieved from www.npspindia.org).

[614] National Surveillance Project A Government of India -WHO initiative. (2006). Current Polio Situation. *AFP Alter Alert*,10(2). (Retrieved from www.npspindia.org); National Surveillance Project A Government of India - WHO initiative. (2007). Progress in Polio Eradication. *AFP Alter*,11(1). (Retrieved from www.npspindia.org).

population. The central concern after the 2006 outbreak was sustaining a consistently high quality of SIAs. There were many covert and consistent reasons for the deterioration in the quality of SIAs and why a large number of susceptible children were missed despite repeated SIAs.

Strong government engagement and direct oversight were critical for sustaining the high quality of the program. But direct oversight by the government of UP was infrequent and inconsistent in high-risk districts of western UP. There were also gaps in sufficient human resources at district and block levels for maintaining appropriate oversight and supervision of the program. A large number of medical officers' positions (30 per cent) remained vacant at block level in highest-risk districts.[615]

Missing OPV immunization of susceptible children and maintaining a huge gap in immunization was the result of gaps in the SIAs monitoring system, inappropriate vaccine administration practices by vaccinators and persistent vaccine avoidance behaviour among the community. There were gaps in the existing monitoring of SIAs which sustained gaps in immunization. In addition to unimmunized children identified through the "missed P houses indicator", a significant percentage of susceptible children were missed from the conventional monitoring systems of SIAs.[616] This created a large pool of un-immunized and/or inadequately immunized children continuously sustaining the circulation of poliovirus resulting in a resurgence in Western UP. From 8-10 per cent of missed houses identified in conventional SIA monitoring, an additional 5.5 per cent of susceptible children houses were missed in western

[615] Despite repeated recommendation of IEAG to state government of UP vacant medical positions were not filled. (National Surveillance Project A Government of India -WHO initiative. (2006). Current Polio Situation. *AFP Alter Alert*,10(2). (Retrieved from www.npspindia.org))

[616] An alternative monitoring system called shadow monitoring system was used after 2006 outbreak to estimate efficiently the number of missed houses and proportion of children within the SIAs conventional monitoring system.

UP. Such a large number of susceptible children were missed majorly because of both vaccine team-low performance and vaccine avoidance behaviour followed by the community.

Inappropriate vaccine administration practices followed by vaccinators where proper classification for identifying the eligible children in the houses was not followed contributing to false P identification. Vaccination team was lacking in appropriate vaccine administration skills and was using incorrect techniques for OPV vaccination to children resulting in wastage of vaccine doses.[617] The vaccination team was also lacking interpersonal communication (IPC) skills to effectively interact with families about the importance of OPV doses and facilitating acceptance of vaccines in households.

The disproportionately higher incidence of polio cases in the 2006 outbreak occurred among the minority population despite enhanced communication efforts. Because vaccine-resistant behaviour remained a dominant factor continuing the risk of circulation of poliovirus among minority communities.[618]

Rumours and vaccine resistance towards PPI campaigns and OPV vaccine were one of the core problems in the implementation of eradication initiatives in western UP, particularly Moradabad. Fear and suspicion and dearth of socio-economic and health services were the two primary causes of a large number of cases among Muslim boys under two years of age.[619]

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[617] Incorrect techniques used by vaccinators were e.g., vaccine administered to sleeping child and vaccine dose spill out by children.

[618] National Surveillance Project A Government of India -WHO initiative. (2006). Current Polio Situation. *AFP Alter Alert*,10(2). (Retrieved from www.npspindia.org); National Surveillance Project A Government of India - WHO initiative. (2007). Progress in Polio Eradication. *AFP Alter*,11(1). (Retrieved from www.npspindia.org).

[619] United Nations Children's Fund (UNICEF). (2004). When Every Child counts engaging the underserved communities for polio eradication in Uttar Pradesh, India, Working paper. *United Nations Children's Fund Regional Office for South Asia.* (Retrieved from www.unicef.org)

There were socio cultural barriers which made people reluctant towards the polio eradication program such as lack of awareness about the rationale of repeated administration of polio drops in NID/SNID; there were general suspicion and doubts among people about the motive of the program; negative rumours surrounding the OPV were around the safety and efficacy of vaccines causing infertility/impotency especially among Muslim boys particularly among illiterate population it was conceived that OPV is used as a tool of population control and its larger agenda of government to reduce high birth rate among Muslim community, community had suspicion that different vaccine was used for Muslim population as vaccination agenda is international conspiracy by Jews and US to finish the community; non-acceptance of and resistance was also caused by experiences where polio paralysis occurred among vaccinated children and in few cases resulting in sickness and/or death of children; doubts were raised that OPV contain undesirable constituents forbidden in Islam such as pig's fat/meat, there were suspicion on orally administering polio vaccine compared to usual intravenous method used in vaccination, suspicion also arouse as for Haj (a religious pilgrimage of Muslim community) Saudi government made polio vaccination of adults compulsory and in India state was focusing on vaccinating children, some older generation people who never had polio vaccine felt no need of vaccinating the children as they believe that they are healthy and survived with good health without vaccination, use of coercion in given OPV drops by involving police personal also resulted in total or partial resistance.[620]

[620] United Nations Children's Fund (UNICEF). (2004). When Every Child counts engaging the underserved communities for polio eradication in Uttar Pradesh, India, Working paper. *United Nations Children's Fund Regional Office for South Asia.* (Retrieved from www.unicef.org); United Nations Children's Fund (UNICEF). (2013). *Eradicating polio getting to zero resistance*. UNICEF, Lucknow. (Retrieved from www.unicef.org); Arora, N.K. (2000). *Progress towards polio eradication: Service delivery, socio-cultural and communization barriers in pulse polio immunization in high burden zone in India.* Clinical Epidemiology Unit, All India Institute of Medical Sciences (AIIMS).

It was not only a religious or socio-cultural problem. But a problem of not recognizing the social determinants of health.[621] Reasons for vaccine-related rumours and social resistance to oral polio vaccination (OPV) were largely reported from socially economically marginalized communities in western districts of UP largely deprived of basic amenities, health infrastructure and services. Many of the cases of resistance were reported from the Moradabad districts of UP where the nature of resistance was sporadic and transient guided by rumour. Children in these districts were at a higher risk of polio infection.[622]

The reasons for suspecting polio vaccines were like those experienced earlier in cases of social resistance in Moradabad. There were overall concerns among communities about the safety and efficacy of OPV drops. Further, the overall media was not supportive and was presenting distorting facts about the pulse polio eradication program. This further increased the doubts and suspicion among communities. Religious leaders such as Imams and Moulvis were not very supportive of the program.[623] There was an environment which lacked trust and confidence created among a certain section of the population.

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[621] Dasgupta R, Chaturvedi S, Adhish S.V, Ganguly K.K, Rai S, Sushant, L, & Arora, K.N. (2008) Social Determinants and Polio 'Endgame': A Qualitative Study in High-Risk Districts of India. *Indian Pediatrics*, 359(45).

[622] Dasgupta R, Chaturvedi S, Adhish S.V, Ganguly K.K, Rai S, Sushant, L, & Arora, K.N. (2008) Social Determinants and Polio 'Endgame': A Qualitative Study in High-Risk Districts of India. *Indian Pediatrics*, 359(45); Chaturvedi et al. (2009). Deconstructing Social Resistance to Pulse Polio Campaign in Two North Indian Districts. *Indian Pediatrics*, 974(46); United Nations Children's Fund (UNICEF). (2013). *Eradicating polio getting to zero resistance*. UNICEF, Lucknow; Chaturvedi, G. (2008). *The Vital Drop: Communication for Polio Eradication in India*. Sage Publications India; Ansari, A.M., Khan, Z. & Khan, M. I. (2007). Reducing resistance against polio drops. *The Journal of the Royal Society for the Promotion of Health*, 127(6), 276-279; Ansari et al.(2013). Role of social mobilization in tackling the resistance to polio eradication program in underserved communities of Aligarh, India. *South-East Asia Journal of Public Health*, 3(2), 23-29; United Nations Children's Fund (UNICEF). (2004). When Every Child counts engaging the underserved communities for polio eradication in Uttar Pradesh, India, Working paper. *United Nations Children's Fund Regional Office for South Asia.* (Retrieved from www.unicef.org)

[623]Arora, N.K. (2000). *Progress towards polio eradication: Service delivery, socio-cultural and communization barriers in pulse polio immunization in high burden zone in India.* Clinical Epidemiology Unit, All India Institute of Medical Sciences (AIIMS).

These rumours start just before a NID/SIA and the nature and content of rumours change with time and area. The majority of rumours were circulated by religious leaflets and magazines, addresses given by religious leaders after weekly prayer, through local restricted public announcements using static and mobile (rickshaw bound); through quasi-confirmed religious edicts. It was difficult to reach the sources of these rumours before NIDs as they go out of bounds and often disowned themselves, or take a neutral stand. The sustainability of these rumours was short of life not causing lasting resistance to SIAs. [624]

The rumours, religious orders, and suspicion of OPV together shaped the perception of certain families among the Muslim population to not seek the polio vaccine.[625] There was general fatigue in the community because of repeated rounds of polio immunization.[626] The effort of the government to vaccinate their children from one disease arouse misconceptions and suspicion among people within the context of neglect of other diseases, insufficient primary health care services, and dismal living conditions in which the population was forced to live.[627]

While it was explicitly known that certain households and communities were reluctant to give OPV doses to their children. The communication strategies were focused on changing the behaviour of such families towards OPV vaccination. But after the 2006 outbreak, it became noticeable that there are certain vaccine avoidance behaviour practices followed by

[624]Dasgupta R, Chaturvedi S, Adhish S.V, Ganguly K.K, Rai S, Sushant, L, & Arora, K.N. (2008) Social Determinants and Polio 'Endgame': A Qualitative Study in High-Risk Districts of India. *Indian Pediatrics*, 359(45).

[625] Chaturvedi et al. (2009). Deconstructing Social Resistance to Pulse Polio Campaign in Two North Indian Districts. *Indian Pediatrics,* 974(46).

[626] Chaturvedi et al. (2009). Deconstructing Social Resistance to Pulse Polio Campaign in Two North Indian Districts. *Indian Pediatrics,* 974(46).

[627] Chaturvedi et al. (2009). Deconstructing Social Resistance to Pulse Polio Campaign in Two North Indian Districts. *Indian Pediatrics,* 974(46); Chaturvedi, G. (2008). *The Vital Drop: Communication for Polio Eradication in India*. Sage Publications India; Ansari, A.M., Khan, Z. & Khan, M. I. (2007). Reducing resistance against polio drops. *The Journal of the Royal Society for the Promotion of Health,* 127(6), 276-279.

parents. These practices were followed while administrating the OPV dose where on community requests eligible children's fingers were marked by vaccinators without properly administrating OPV doses. Such improper practices were largely followed in presence of the vaccinators' team and with support. Such covert vaccine avoidance practices by parents were largely not captured in traditional SIAs monitoring systems facilitating the circulation of the virus in the community.[628]

Apart from community resistant behaviour overall failure of the polio eradication program in western UP to reach and immunize children was gaining media attention. The eradication strategies and quality of vaccine used in the polio eradication program were widely discussed and questioned in the newspapers. The negative publicity particularly regarding the quality of OPV and overall eradication initiative was influenced by shaping the attitude and perceptions and motivation of the general public and health workers.

After the 2006 outbreak, more focus and resources were shifted to western UP to adequately address the existing challenges in this area. The Union government of India along with partner organizations[629] focused their attention on providing consistent ground-level support to the state government of UP and Bihar in high-risk areas. For ensuring adequate management and intensive monitoring of SIAs quality in high-risk districts several steps were taken in UP and Bihar such as the appointment of the best staff for management positions,

[628] Vaccine avoidance behavioral practices followed by community with support of vaccination team were – on community request fingers of children marked without giving OPV dose, fingers marked after giving one drop of OPV dose on community request instead of two (largely to newborn and sick children) and, family asked children to spit out vaccine two drops of OPV given and vaccinators ignores and mark the children fingers. (National Surveillance Project A Government of India -WHO initiative. (2006). Current Polio Situation. *AFP Alter Alert,*10(2). (Retrieved from www.npspindia.org))

appointment of technical staff by district magistrates as needed, and increased re-deployment of WHO NPSP experienced officers, UNICEF SMNET staff in high-risk districts.[630]

Efforts were also made by the Indian Academy of Pediatrics (IAP) and Indian Medical Association (IMA) in endemic states made efforts to involve a local level network of doctors and other professional organizations in polio eradication initiative to counter the negative press environment about the polio eradication initiatives and dispelling the rumour to rebuilt the positive belief about the quality of OPV and eradication strategies among the general public.

Expansion of SMNET and communication efforts continued along with underserved and transit strategy for better access to children. The focus was given to including vulnerable social groups such as nomads, slum population, and migrant population. Incentives were also given to vaccinators and the community as add-ons under special communication strategies for sustaining the motivation. The focus was also given to building on the inter-personal skills of vaccination teams and supervisors and improved classification of X houses for better conversion of convertible and non-convertible X. More involvement of local medical practitioners, community-specific influencers, and local government officials for tracking the missed children at the district and block level.

Because routine immunization (RI) was consistently missing a majority of infants and young children creating a gap in immunity more emphasis was given to improving RI every year. High-priority districts of UP and Bihar continued to be targeted for intensive RI efforts under the guidance of NTAGI and IEAG. A major emphasis was given to continuous monitoring of

[630] Indian Expert Advisory Group (IEAG). (2006). *The Fifteenth Meeting of the India Expert Advisory Group for Polio Eradication*, Delhi, India 4-5 May. (Retrieved from http://www.npspindia.org); National Surveillance Project A Government of India -WHO initiative. (2006). Current Polio Situation. *AFP Alter Alert,*10(2). (Retrieved from www.npspindia.org); National Surveillance Project A Government of India -WHO initiative. (2007). Progress in Polio Eradication. *AFP Alter,*11(1). (Retrieved from www.npspindia.org)

service delivery gaps and problems in RI services to ensure high coverage. Some improvements were made where immunization weeks were conducted to avail vaccination services to communities in high-risk areas previously underserved in UP and Bihar. But sustained high level of coverage was required particularly for infants in high-risk areas of UP and Bihar. Similarly, it was important for polio-free areas to maintain high-level coverage levels to avoid the risk of re-introduction of poliovirus.[631]

4.12 Social Determinants of Health (SDH) and Failing Immunity of OPV in Western UP

Apart from operational factors, there were other environmental factors contributing to the continued circulation of poliovirus in the area. Endemicity of a few clusters in UP was attributed to lacunae in program implementation. But context-specific social determinants of health were also contributing to the continued transmission of poliovirus in these endemic clusters of UP. Within the UP eastern and south-central parts of the state achieved zero-polio case status several years ago and were reporting a smaller number of polio cases over years. On the other side western UP particularly a few endemic clusters of western UP were reporting a higher number of polio cases repeatedly.

Social determinants factors driving the endemicity of a few clusters of UP were different from eastern and south-central parts. An unpublished study comparing the social determinants factors of endemic clusters of western UP to clusters reporting zero cases in south-central and eastern UP reported interesting findings on social determinants of health.[632]

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[631] Indian Expert Advisory Group (IEAG). (2006). *The Fifteenth Meeting of the India Expert Advisory Group for Polio Eradication*, Delhi, India 4-5 May. (Retrieved from http://www.npspindia.org); National Surveillance Project A Government of India -WHO initiative. (2006). Current Polio Situation. *AFP Alter Alert*,10(2). (Retrieved from www.npspindia.org); National Surveillance Project A Government of India -WHO initiative. (2007). Progress in Polio Eradication. *AFP Alter*,11(1). (Retrieved from www.npspindia.org)

[632] Clusters of seven districts selected for study which reported zero-case districts in eastern and south-central parts of the state were – Lalitpur, Rae Bareli, Ballia, Jhansi, Hamirpur, Kushinagar and Sonbhadra. In western UP clusters of endemic districts which reported highest number of WPV cases are – Moradabad, Budaun, Muzaffarnagar, Bareilly, Meerut, JP Nagar (Jyotiba Phule Nagar) and Ghaziabad.

While high population density, urbanization, and proportion of minority Muslim population residing in urban areas is 2-4 times higher in endemic districts of western UP compared to south-central and eastern. Contrary to endemic districts in western UP, the south-central and eastern districts in UP have higher poverty levels, poor access to toilet facilities, lower ranking in district socio-economic and health development indicators, better primary health care infrastructure, greater community participation (in Village Health and Sanitation Committees (VHSC) and Rogi Kalyan Samitis (RKS)), higher routine immunization coverage and high usage rate of oral rehydration salt. Despite this, the overall performance of SIAs rounds and performance to interrupting poliovirus was better in south-eastern clusters of districts than in endemic districts of western UP.

The study concluded that social determinants of health particularly high population density, rapid urbanization, a high proportion of minority population, and low routine immunization coverage are driving the endemicity of districts in western UP.[633]

Similar findings were also stated for the high endemicity of western UP districts after the 2006 outbreak. Despite a high proportion of vaccinated children, the size of the targeted children population was very high and increasing every year. It was difficult for the program to ensure complete coverage of OPV because of the high population density, high birth rate and very high young children population. Concurrently very poor sanitary conditions and high non-polio enterovirus (NPEV) incidence were facilitating a low level of OPV effectiveness thereby continuing the transmission of poliovirus.[634]

[633] Dasgupta R., et al. (nd). *Engaging with the Enigma of Endemicity: Lessons from Polio Elimination in Uttar Pradesh (India)*. Unpublished study

[634] Non-polio enterovirus (NPEV) rates signify that there are other enterovirus or bacterial infections within community which does not allow high OPV effectiveness for building required immunity in children.

The high population density in Moradabad and its sub-regions were sustaining virus transmission. The high population density was enabling child-to-child virus transmission.

Immunity gaps were not only caused by the sub-optimal quality of SIAs and deteriorating routine immunization coverage as seen in earlier phases of the program in high-risk areas. But the high birth rate in the Moradabad region was also contributing to the continuous addition of a large number of infants to the population every year. It was important for the program to close the immunity gaps with high-quality of SIA rounds to stop transmission.

But after the 2006 outbreak, it became clear that the major problem in interrupting the poliovirus transmission in the area was low immunity among young children. Despite high coverage, the per-dose efficacy of OPV among very young children of less than three was insufficient to build adequate immunity. In endemic areas of western UP, the wild poliovirus was infecting largely young children less than 3 years of age (13 per cent) and 2-3 years of age (14 per cent) and most of them less than two years old (73 per cent). Older children above 3 years of age who were mostly immunized were reporting fewer polio cases compared to younger children, particularly those under two years of age who didn't get enough opportunity to get OPV doses. Additionally, routine immunization in these areas was very low making it further difficult for young children to get the OPV vaccine. Thus, the low immunization status of younger children was continuing the survival of poliovirus in western UP.[635]

[635]Indian Expert Advisory Group (IEAG). (2006). *The Fifteenth Meeting of the India Expert Advisory Group for Polio Eradication*, Delhi, India 4-5 May. (Retrieved from http://www.npspindia.org); National Surveillance Project A Government of India -WHO initiative. (2006). Current Polio Situation. *AFP Alter Alert,*10(2). (Retrieved from www.npspindia.org); National Surveillance Project A Government of India -WHO initiative. (2007). Progress in Polio Eradication. *AFP Alter*,11(1). (Retrieved from www.npspindia.org).

While mOPV remained the central strategy for increasing population immunity in high-risk areas for children under five years of age. One of the major strategies to improve the immune response in the highest risk areas to build immunity in the younger population was the introduction of the birth dose of mOPV. This was one of the additional efforts implemented within the program in western UP high-risk areas to enhance immune response. The birth dose of mOPV1 was introduced for both institutional and non-institutional births administered mOPV1 dose mostly within 72 hours of birth. Using the support of local-level community health workers, government officials and other community members such as local Imam all the new-born children in high-risk areas were tracked for better coverage of mOPV1 birth dose.[636]

It was paramount important for the polio eradication initiative in the country to not only reach eligible children and immunize them. But to ensure that OPV vaccination immune response is developed in targeted children. Lack of required immune response in children is a major risk factor exposing the susceptible children to poliovirus infection thereby continuing the transmission.

Building adequate immunity in susceptible children became a major area of concern within the whole eradication initiative, particularly after the 2006 outbreak. It was realized that it was not only operational problems and resistance of families which caused the failure to reach the eligible children in high-priority areas. It was also immune failure where lower efficacy of OPV was failing to adequately immune children against poliovirus in UP.

[636]Indian Expert Advisory Group (IEAG). (2006). *The Fifteenth Meeting of the India Expert Advisory Group for Polio Eradication*, Delhi, India 4-5 May. (Retrieved from http://www.npspindia.org); National Surveillance Project A Government of India -WHO initiative. (2006). Current Polio Situation. *AFP Alter Alert,*10(2). (Retrieved from www.npspindia.org); National Surveillance Project A Government of India -WHO initiative. (2007). Progress in Polio Eradication. *AFP Alter*,11(1). (Retrieved from www.npspindia.org).

This clearly showed that the failure of the PPI program in northern India particularly in UP high-risk areas was not only the issue of strengthening of PPI. The immunity gaps caused by the low immunity of children were a major risk to the eradication efforts in the country. The per-dose efficacy of OPV in northern parts of India particularly western UP was low compared to the rest of India.

Low immunity response to polio and polio cases among highly immunized children was discussed extensively by public health experts, academicians and scientists as the major overall risk to the program despite introducing mOPV1 in 2005. The use of inactivated polio vaccine (IPV) was one of the alternatives widely discussed by these experts to be used against OPV, particularly in high-risk areas as a means to interrupt the transmission of polio in India. Studies on the efficacy of IPV were conducted in the 1980s in India. Showed very high vaccine efficacy of IPV (three doses) in India. Similar studies in the 1970s were conducted in Netherlands showing the strong efficacy of IPV. It was already studied extensively before the start of the PPI program that IPV is best suited for the Indian context. But contrary to scientific research evidence IPV was used in India.[637]

But within the program polio experts involved were convinced there was no problem with the vaccine used (OPV) or vaccine quality. The low immunity among children and in highly vaccinated children was primarily due to two reasons as per the experts – 1) OPV is resulting in lower vaccine effectiveness because of a high incidence of other enterovirus or bacterial infections causing a higher incidence of diarrhoea and resulting in lesser opportunity within children to develop immunity, 2) most of the children under five years of age are

[637] John, T.J. (2016). India's Research Contributions Towards Polio Eradication (1965-2015). *Indian Journal of Pediatrics*,53, (1-6).

immunized. Thus, polio cases will occur among vaccinated children as virus transmission continues in high-risk areas known for lower vaccine efficacy.[638]

"The problem or challenge became the associated social determinants of oral polio vaccines implementation. There was large presence of diarrheal diseases among children and because of this it let the vaccine flush out from the gut of children easily. Leading to failure of maintain the immunity. This required children being given more then 3-4 doses of vaccines every time in every rounds. There was also not any system to track children who was given vaccine or who was not given vaccines. As the vaccination cards were not updated the vaccine mobilisers depend on the recall of mothers so there was lack of evidence-based on which the OPV was given to children." [639]

Major efforts were done in the past to achieve a high immune response to OPV doses in children in high-risk areas. Such as introducing mOPV in 2005 against tOPV and increasing the number of SIAs rounds in the rest of India thereby increasing the number of OPV doses in children in high-risk areas.

Addressing the problem of deteriorating immune response in high-risk areas was critical for the success of the program. But within the western UP in high-risk areas clusters, districts developing an immune response was difficult despite multiple doses of OPV. After the 2006 outbreak, the feasibility of using inactivated polio vaccine (IPV) was one of the supplementary strategies considered in high-risk areas. The IPV was considered only as means to provide individual protection to children in high-risk areas for achieving individual immunity were gaining high levels of immunity is difficult. Overall IPV's role in improving the general immunity of children for interrupting the transmission of polio against mOPV in

[638] Indian Expert Advisory Group (IEAG). (2006). *The Fifteenth Meeting of the India Expert Advisory Group for Polio Eradication*, Delhi, India 4-5 May. (Retrieved from http://www.npspindia.org); National Surveillance Project A Government of India -WHO initiative. (2006). Current Polio Situation. *AFP Alter Alert*,10(2). (Retrieved from www.npspindia.org); National Surveillance Project A Government of India -WHO initiative. (2007). Progress in Polio Eradication. *AFP Alter*,11(1). (Retrieved from www.npspindia.org)

[639] Interview

India was not considered. Studies on understanding the operational feasibility of giving supplementary doses of IPV to children in critically high-risk areas were done.[640]

Within the program, there was an assurance that it is possible to stop polio transmission based on examples of other countries such as Egypt where risk factors similar to UP and Bihar have succeeded in stopping the polio transmission by implementing the high-quality strategies.

The problem with the use of the polio vaccine was still mounting in the country among public health scholars and professionals despite introducing mOPV1 in 2005. The OPV was largely discussed widely by scientists, public health academicians and activists in the country. But it was acknowledged by IEAG only after the 2006 outbreak.

In the 2006 outbreak, the low population immunity was created as the result of low routine immunization coverage of tOPV. The mOPV1 introduced in 2005 in high-risk areas was not adequately received by children during PPI campaigns implemented in a span of one year. While field trials on comparative measurement of mOPV1 and mOPV3 were ongoing in 2006. There was no doubt among polio experts on the efficacy of mOPV in causing immune response against wild poliovirus (consider 3 times higher per dose than tOPV).[641]

Major efforts put forth in states of UP to improve the overall performance of the program resulted in an improvement of the quality of SIAs in high-risk areas and a reduction in missed houses in a few very high-risk urban zones. But long term sustained improvement was required to achieve high coverage and decrease the immunity gaps. Despite improvements

[640] Indian Expert Advisory Group (IEAG). (2006). *The Fifteenth Meeting of the India Expert Advisory Group for Polio Eradication*, Delhi, India 4-5 May. (Retrieved from http://www.npspindia.org); National Surveillance Project A Government of India -WHO initiative. (2006). Current Polio Situation. *AFP Alter Alert*,10(2). (Retrieved from www.npspindia.org); National Surveillance Project A Government of India -WHO initiative. (2007). Progress in Polio Eradication. *AFP Alter*,11(1). (Retrieved from www.npspindia.org)

[641] National Surveillance Project A Government of India -WHO initiative. (2006). Current Polio Situation. *AFP Alter Alert*,10(2). (Retrieved from www.npspindia.org)

in SIA quality in western UP gaps remained to require broader and sustained initiatives for needed improvements.

4.13 Problems with the Final Phase of Eradication

By the end of 2007, the polio program was fully evolved program to capture poliovirus transmission and reach anywhere in the country with polio vaccines to eligible children. Reaching and immunizing children with continuous efforts was strengthened with continued emphasis on local level micro-planning of immunization activities for each PPI campaign. The polio surveillance system was developed to the fullest level adequately monitoring high-risk areas by expanding the number of AFP reporting units. But the process of eradicating polio in India has by now become long with continuous delays in ending the poliovirus. This not only increased the financial costs and resources required for running the program but also was demotivating for all the people involved with the program. Globally the repeated frequency of polio rounds in India was frustrating.

"What was frustrating was the frequency of administration of polio rounds in India."[642]

The government of India had to continuously fill the funding gap required for both vaccine and operational costs through the mobilization of funds from external and internal resources.

There was no low in confidence among the country-level polio experts that poliovirus transmission could be stopped during the coming low season and the overall strategies followed within the program were correct and appropriate. All it was needed towards the final phase of

[642] Interview

the program to continue focus, determination and momentum for achieving the eradication goals in the environment continuous challenges in eradicating polio in northern belts.

By mid of 2007 population immunity was again high in India after the 2006 outbreak including in the northern parts of India against the WPV1 poliovirus. By mid of 2008, India achieved a major success where type 1 poliovirus transmission was on the verge of ending. This was possible because of the continued focus of the program on implementing large-scale sub-national rounds conducted since mid-2006 and improvement in SIA quality in endemic reservoir areas. The population immunity against WPV1 among children in India was sustained throughout 2007 and 2008 through implementing intensive efforts. This was a major success for the program in limiting the WPV1 transmission in the country as India was leading the global polio eradication of WPV1.[643]

The focus of the program by mid of 2007 was to maintain the high immunity achieved, stop the transmission of WPV1 in endemic reservoir areas and follow the measures to suppress WPV3 transmission in western UP through the implementation of appropriate strategies.[644]

Multiple campaigns using mOPV1 were implemented targeting the endemic regions of UP and Bihar states. Subsequently, the number of reported polio cases of type 1 declined and the poliovirus type 1 transmission decreased markedly in UP by mid of 2007, particularly in Moradabad endemic districts reported no cases for a period of over 6 months. But the risk of WPV1 transmission and its re-introduction continues from other infected areas.

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[643] Indian Expert Advisory Group (IEAG). (2007). *The Seventeenth Meeting of the India Expert Advisory Group for Polio Eradication*, Delhi, India 29-30 May. (Retrieved from http://www.npspindia.org); National Surveillance Project A Government of India -WHO initiative. (2008). Current Situation. *AFP Alter*,12(2). (Retrieved from www.npspindia.org).

[644] Indian Expert Advisory Group (IEAG). (2007). *The Seventeenth Meeting of the India Expert Advisory Group for Polio Eradication*, Delhi, India 29-30 May. (Retrieved from http://www.npspindia.org); National Surveillance Project A Government of India -WHO initiative. (2008). Current Situation. *AFP Alter*,12(2). (Retrieved from www.npspindia.org).

An independent team was sent to India's endemic states by the WHO director-general to evaluate the constraints on the success of the program in 2009.

The global polio eradication initiative (GPEI) on the recommendation of the World Health Assembly (WHA) in 2008 introduced a new strategy to achieve polio eradication. This new strategic plan was focused on interrupting the WPV transmission in Asia, Africa and overall enhancing global surveillance and outbreak response and strengthening the overall immunization systems. The GPEI replaced the multi-year planning process with a one-year 2009 program of work. This included examining the major obstacles to achieving the interruption of WPV transmission in each and every endemic area through independent evaluation; speeding up of development and clinical trials on vaccine approaches and new vaccines, and identifying a new approach to reach children missed from vaccination.[645]

The problem of OPV failure to immunize a substantial proportion of the population. A team of polio experts at the request of Dr Margaret Chan, the Director-General of the World Health Organization was constituted and came down to India in August of 2009 to review the situation of polio eradication and its challenges in India. The team was of the view that understanding the ecology of poliovirus in the western UP and Bihar can explain the constraints in eradicating polio in these two states.[646]

There were several findings concluded by the WHO team of experts. 1) Routine immunization was insufficient in giving the dose of OPV to children. The routine coverage of tOPV was 40 per cent in Uttar Pradesh and 53 per cent in Bihar. Strong routine immunization in these two states was a critical need as it was inversely correlated to achieving eradication

[645] World Health Organization. (2010). *Every Last Child, Polio global eradication initiative strategic plan 2010 -2012*. Geneva, Switzerland. (Retrieved from www.polioeradication.org)
[646] World Health Organization. (2009). Independent Evaluation of major Barriers to Interrupting Poliovirus. Transmission in India. (Retrieved from www.polioeradication.org)

and for the post-polio eradication phase. 2) Cold chains at district and block levels were old and in a crumbling state with no adequate arrangement for repair, back up and replacement of their parts. 3) the trivalent OPV (tOPV) has limited immune response in the states of UP and Bihar as seen in other tropical developing countries. But there was no clear evidence for low immunogenicity. But despite this limitation of tOPV, polio has been eradicated from the majority of the world's countries and there has been a reduction in the genetic diversity of poliovirus in UP and Bihar. The continued circulation of poliovirus after many doses of OPV in northern India could be caused by low gut immunity or the high density of wild poliovirus in India continuing the excretion and its transmission. 4) Introduction of IPV was not seen as an alternative to OPV to increase immune response was not seen as a viable option because of the operational cost and logistics needs to be required compared to OPV administration through mass campaigns. Even in routine coverage, it was not feasible to introduce IPV as DTP3 coverage was 50 per cent and the success of the strategy would require higher coverage. Thus, IPV introduction was seen as a challenge. 5) there were unique environmental conditions contributing to the poor effectiveness of OPV such as poor sanitation, poor water quality, high density of population particularly in peri-urban areas, poor nutrition of children and high prevalence of diarrhoea. 6) Although the polio program was highly visible among communities in Uttar Pradesh and Bihar. There was a need to increase communication about the program among the mobile transit population. Broadening of communication messages including safe water, breastfeeding and hygienic measures was required. As community resistance is used as a tool to draw the attention of the government to other neglected socio-economic needs, 7) It was noted that there is increasing frustration among donors and senior government officials about shifting timelines and not achieving the eradication. Also, there was confusion in ownership of the program among the government and major program partners. Although there is a sense of pride and a strong commitment to the program at state, district and sub-district

levels. There was also a problem in sustaining the high morale for the program and the required intensity of polio activities.[647]

Within the context of the above existing problems evaluated by the WHO team in India, efforts were intensified to reach the last child with the polio vaccine. The endemic states of UP and Bihar were still at the highest risk for the progress of the program. Changing the perception of community with the intensification of social mobilization activities particularly addressing the social determinants of health in the endemic became essential. In 2009 UNICEF designed and implemented the 107-block strategy in endemic states of UP and Bihar to vigorous implementation of underserved communication mobilization activities in these blocks. These blocks were at the highest risk of poliovirus transmission.[648]

The exclusive focus of the program on the use of mOPV1 in SIAs increased the immunity gaps for type 3 poliovirus in the endemic northern regions. Less number of children were immunized with mOPV3 in SIAs rounds. This increased the risk of the type 3 poliovirus in western districts of UP as the WPV type 3 virus was moving away geographically from endemic western districts. By 2007 there were 24 WPV3 cases reported from 21 western districts of UP compared to one WPV1 reported case from 24 districts of western UP. By mid of 2008, India achieved high levels of population immunity against WPV1. As the WPV1 type poliovirus transmission was declining the vaccine choice was switched to mOPV3 in selected districts of western UP. Extensive use of monovalent oral polio vaccine type 3 in both states

[647] World Health Organization. (2009). Independent Evaluation of major Barriers to Interrupting Poliovirus. Transmission in India. (Retrieved from www.polioeradication.org)

[648] Chaturvedi, G. (2008). *The Vital Drop: Communication for Polio Eradication in India*. Sage Publications India; United Nations Children's Fund (UNICEF). (2004). When Every Child counts engaging the underserved communities for polio eradication in Uttar Pradesh, India, Working paper. *United Nations Children's Fund Regional Office for South Asia.* (Retrieved from www.unicef.org); United Nations Children's Fund (UNICEF). (2013). *Eradicating polio getting to zero resistance*. UNICEF, Lucknow. (Retrieved from www.unicef.org)

remained low in 2008. The stage was set for interrupting the transmission in 2009. By 2008 end of poliovirus transmission in India was in sight. The program strategy for the second half of 2008 was to stop WPV1 transmission while keeping WPV3 suppressed. In 2008 mOPV3 was used in SIAs in endemic regions after controlling mOPV1. Later in December 2009 bivalent OPV (bOPV) was used in the PPI campaigns. The goal of stopping poliovirus circulation was the final stage set for polio eradication in 2009 WPV3. The focus of the program remained on increasing the quality of SIAs in high-risk blocks, particularly the areas in UP where both WPV1 and WPV3 transmission was going on. The transmission was going on in districts of central UP, southern districts of western UP centered in Farrukhabad and in Moradabad, Bareilly and Rampur and Badaun in western UP. At this stage, the main risk for the program was mobile populations carrying the virus from endemic reservoirs areas into other polio-free states.[649]

Use of supplementary dose of IPV a plan was made to use as a combination vaccine along with DPT (Diphtheria, Pertussis and Tetanus). For its implementation limited geographical use of IPV additional dose in districts of western UP where the virus was continually circulating type 1 and type 3 wild poliovirus was considered. It was seen that a small dose of IPV could close the immunity gap considered as a supplementary strategy which could not be achieved despite repeated rounds of OPV. But there were operational challenges to operationalizing IPV doses such as communication to implement this strategy it was important to ensure community participation and acceptance of the vaccine and the extremely limited global supply of IPV. It was recognized that there was a substantial limited role and

[649] National Surveillance Project A Government of India -WHO initiative. (2008). Current Situation. *AFP Alter*,12(2). (Retrieved from www.npspindia.org); National Surveillance Project A Government of India -WHO initiative. (2009). Current Situation. *AFP Alter*,13(1). (Retrieved from www.npspindia.org); Indian Expert Advisory Group (IEAG). (2007). *The Seventeenth Meeting of the India Expert Advisory Group for Polio Eradication*, Delhi, India 29-30 May. (Retrieved from http://www.npspindia.org)

impact of IPV strategy. There were operational challenges to achieving 50-75 per cent coverage and IPV had a limited impact on mucosal immunity because the primary mode of wild poliovirus transmission was faecal-oral route in western UP. Thus, as per the IEAG, this strategy had a very minimal role in reducing cases. The field-level study on the feasibility of IPV was underway but before polio virus elimination IPV was never used as a supplementary dose in western UP. It was only after India became polio-free that IPV was used.

Although in United States by year of 1999 the use of oral polio vaccine was abandon following increasing concerns on increasing number of polio cases caused by oral polio vaccine.[650] Oral polio vaccine use continued as part of global polio eradication initiative in developing countries.

Despite concerns on safety of oral polio vaccine it remained a popular product promoted by WHO for its use in worldwide polio eradication campaigns. The introduction of IPV in the PPI program was not supported globally by institutions such as WHO and UNICEF. Problems of operational and logistics feasibility of implementing IPV were a concern. The introduction of IPV was seen to increase the overall cost of the program both vaccine procurement cost as well as program implementation cost. Changing IPV has not seen a solution to the problem of low immunity in children caused by a pre-existing infection in the guts. It was also a policy dilemma for international-level polio experts and policymakers for introducing change. Such plans were criticized by WHO as of less scientific interest in achieving rapid interruption of poliovirus transmission in India. The introduction of IPV was seen as an end-game strategy for the elimination of the virus.[651]

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[650] Interview

[651] Indian Expert Advisory Group (IEAG). (2009). *Twentieth Meeting of the India Expert Advisory Group for Polio Eradication,* Delhi, India 24-25 June. (Retrieved from http://www.npspindia.org); Indian Expert Advisory

"At that time there were many debates such as replace OPV with IPV, use of IPV along with OPV in high-risk districts but it would have caused more confusion, use of resources, as IPV require expensive, required trained personnel, etc. Change of vaccine would have required different changes in vaccine delivery system. If we have used IPV and OPV both one cadre using OPV and another IPV this would be had been confusing, difficult and more expensive for the program." [652]

"Change of IPV would impacted the cost and logistical implementation, it would have not solved the gut immunity problem, required new techniques, caused management issues etc. IPV introduction along with OPV don't know whether effective specially for high-risk states but had caused management issues. Same work with different health personnel. If IPV was replaced with OPV it would have caused high cost not just vaccine cost but programmatic cost. So, introducing the IPV was a policy dilemma among the health professionals at global level of UN agencies, and global level. Although there was a demand to introduce and it needs."[653]

There were major efforts put into the program to improve the overall quality of the SIA rounds. The immunity of young children in endemic areas of UP and Bihar significantly improved the immunization status of younger children. Towards of the end of the program, the overall SIAs quality remained very high, particularly in high-risk areas of UP and Bihar. Consistent efforts were put in to identify pockets of areas with immunization of the population. Furthermore, in endemic areas of UP and Bihar efforts were made to fill the health workers' vacancies at the district and block level and to improve general health service delivery in the states.[654]

Tracking of new-borns during SIA was established in Bihar and UP this improved the overall capacity of the program to reach young children in SIA rounds and closer monitoring of coverage. Communication and social mobilization activities in high-risk areas had a positive impact on reducing the missed children. Participation of ASHA workers were increased both

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Group (IEAG). (2010). *Twenty-Second Meeting of the India Expert Advisory Group for Polio Eradication*, Delhi, India 1-2 November. (Retrieved from www.polioeradication.org)

[652] Interview

[653] Interview

[654] Indian Expert Advisory Group (IEAG). (2007). *The Seventeenth Meeting of the India Expert Advisory Group for Polio Eradication*, Delhi, India 29-30 May. (Retrieved from http://www.npspindia.org); National Surveillance Project A Government of India -WHO initiative. (2008). Current Situation. *AFP Alter*,12(2). (Retrieved from www.npspindia.org); National Surveillance Project A Government of India -WHO initiative. (2009). Current Situation. *AFP Alter*,13(1). (Retrieved from www.npspindia.org)

to improve the quality of SIA rounds and in supporting routine immunization activities in UP and Bihar. There was a three-fold increase in honorarium for polio vaccination campaigns.[655]

Further to improve the high quality of SIAs focus more was given to identifying and mapping mobile populations from Bihar and UP. Mobile population migrating to Punjab, Haryana, Gujrat and Delhi and Mumbai was a particular risk of spreading and maintaining the risk of circulation of wild poliovirus outside of endemic areas. As a strategy to better track, the migrants for polio immunization trains used by migrants were targeted for in-out movement from UP and Bihar. In routine immunization of the program, the focus was given to immunizing mobile and migrant populations.[656]

But despite implementing extensive plans for improving routine immunization coverage the progress of routine immunization coverage continues to remain slow in UP and Bihar. Routine immunization was consistently missing the majority of infants creating a gap in immunity. Two of the major concurrent problem with the overall polio eradication program was vaccine insecurity and lack of sufficient funds. The timely availability of mopv1 continued to be a problem as there was only one reliable licensed manufacturer in India. For reducing the problem of vaccine insecurity and availing the strategic flexibility additional mOPV

[655] Indian Expert Advisory Group (IEAG). (2007). *The Seventeenth Meeting of the India Expert Advisory Group for Polio Eradication*, Delhi, India 29-30 May. (Retrieved from http://www.npspindia.org); National Surveillance Project A Government of India -WHO initiative. (2008). Current Situation. *AFP Alter*,12(2). (Retrieved from www.npspindia.org)

[656] Indian Expert Advisory Group (IEAG). (2007). *The Seventeenth Meeting of the India Expert Advisory Group for Polio Eradication*, Delhi, India 29-30 May. (Retrieved from http://www.npspindia.org); National Surveillance Project A Government of India -WHO initiative. (2008). Current Situation. *AFP Alter*,12(2). (Retrieved from www.npspindia.org); National Surveillance Project A Government of India -WHO initiative. (2009). Current Situation. *AFP Alter*,13(1). (Retrieved from www.npspindia.org); Indian Expert Advisory Group (IEAG). (2009). *Twentieth Meeting of the India Expert Advisory Group for Polio Eradication*, Delhi, India 24-25 June. (Retrieved from http://www.npspindia.org)

manufacturers were licensed in India. The timely release of government funds to UNICEF for vaccine procurement was a frequent problem for the timely availability of vaccines.[657]

4.14 Turning the Page on Polio Elimination

By the year of 2010, India was on the verge of eradicating the polio virus from the country. There were seen historical reductions in the number of polio cases in India. Both the endemic reservoirs state UP and Bihar was reporting no wild poliovirus type 1 (WPV1) cases and type 3 (WPV3) since late 2009 and early 2010. Particularly immunity against type 1 poliovirus increased to a very high level and significantly against type 3 among children 6-7 months of age. Thus, India reached the final phase of polio eradication with very low levels of transmission of both WPV1 and WPV3 along with rising immunity.[658]

Various factors brought reductions in the number of polio cases and poliovirus transmission dramatically. 1) For improving immunization coverage of SIAs, highest risk areas in western Uttar Pradesh and Bihar were targeted in every round of SIAs consistently; 2) Bivalent OPV sustained the high levels of immunity against poliovirus type 1 achieved in 2009 while increasing immunity to type 3. 3) Implementation of 107 block plan also contributed to intensifying the immunization coverage, particularly in improving the routine immunisation.4) Community resistance to OPV reduced, and support increased for the polio program. [659]

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[657] Indian Expert Advisory Group (IEAG). (2009). *Twentieth Meeting of the India Expert Advisory Group for Polio Eradication*, Delhi, India 24-25 June. (Retrieved from http://www.npspindia.org); National Surveillance Project A Government of India -WHO initiative. (2008). Current Situation. *AFP Alter*,12(2). (Retrieved from www.npspindia.org); National Surveillance Project A Government of India -WHO initiative. (2009). Current Situation. *AFP Alter*,13(1). (Retrieved from www.npspindia.org)

[658] Indian Expert Advisory Group (IEAG). (2009). *Twentieth Meeting of the India Expert Advisory Group for Polio Eradication*, Delhi, India 24-25 June. (Retrieved from http://www.npspindia.org); Indian Expert Advisory Group (IEAG). (2010). *Twenty-Second Meeting of the India Expert Advisory Group for Polio Eradication*, Delhi, India 1-2 November. (Retrieved from www.polioeradication.org)

[659] Indian Expert Advisory Group (IEAG). (2010). *Twenty-Second Meeting of the India Expert Advisory Group for Polio Eradication*, Delhi, India 1-2 November. (Retrieved from www.polioeradication.org)

But the risk of migrant and mobile populations continued as they continued to be a source of poliovirus transferring from one mobile group to another in the non-endemic states of Delhi, Maharashtra and West Bengal and Punjab. Intensification of activities was implemented for better surveillance and immunization of migrant and mobile populations.

For the final push of the polio eradication initiative in India, major risks for missing circulation of poliovirus circulation were migrant mobile population and endemic reservoir areas. There were majorly two strategies emphasized 1) reducing the risk of persistence poliovirus transmission in highest risk endemic areas of western UP and central Bihar through 107 blocks plan; 2) reducing the risk of survival of wild poliovirus among migrant and mobile population, the migrant strategy was intensifying to identify in endemic and non-endemic areas for better coverage of immunization and surveillance activities of migrants.

In the year of 2010, India recorded the lowest level of polio transmission. This was continued in the year 2011where. India reported only one case of polio. The last case of polio was written on January 13 2011, in the Howrah district of West Bengal. Historically it was very significant for India, where transmission of both wild poliovirus (WPV) type 1 and WPV type 3 was recorded at the lowest level in both endemic reservoir areas of UP and Bihar. The success achieved in UP and Bihar ensured that India is in the last lap of eliminating the polio virus.[660]

"The experience from U.P. clearly highlights that if have a commitment at all levels to eradicate a disease, including the highest level of political and administrative power, health programs can be successful. A properly planned and executed program, Social mobilization, Multisectoral coordination and mid-course corrections in different elements of the program and its implementation are some of the positive and unique features of PPI program which have resulted in eventual eradication of polio from India."[661]

[660] Indian Expert Advisory Group (IEAG). (2010). *Twenty-Second Meeting of the India Expert Advisory Group for Polio Eradication*, Delhi, India 1-2 November. (Retrieved from www.polioeradication.org); Indian Expert Advisory Group (IEAG). (2011). *Twenty-Third Meeting of the India Expert Advisory Group for Polio Eradication, Delhi*, India 13-14 July. (Retrieved from www.polioeradication.org)
[661] Interview

As India was on the journey to eliminate viruses, significant risks to the eradication initiatives remained. The program remained vigilant to detect any WPV in the country, particularly from historic reservoir areas, circulation of poliovirus migrant mobile and under severed communities, and international importation of wild poliovirus. Any source of WPV transmission in the country was considered a public health emergency and must be responded to by multiple high-quality mops-up vaccination campaigns. The last known area of WPV transmission in the country was recorded in West Bengal.[662]

Since 2011 there has been no reported case of wild poliovirus transmission in the country. India's struggles to achieve polio-free status came to an end in 2014 after successfully maintaining zero polio cases for three years. India had finally turned over the page on polio eradication. In 2014 the WHO South-East Asia region was given the certification of polio-free status. India's victory in achieving the polio-free status was acclaimed globally.

"Where there is a will, there is a way- PPI Program in India has proved this phrase."[663]

India has a rhetoric success globally in achieving the polio-free status in 2014 but it took more than two decades for India to eliminate the polio virus. Taking forward the legacy of polio eradication in routine immunization mission is the ultimate objective of the program

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[662] Indian Expert Advisory Group (IEAG). (2010). *Twenty-Second Meeting of the India Expert Advisory Group for Polio Eradication*, Delhi, India 1-2 November. (Retrieved from www.polioeradication.org); Indian Expert Advisory Group (IEAG). (2011). *Twenty-Third Meeting of the India Expert Advisory Group for Polio Eradication, Delhi*, India 13-14 July. (Retrieved from www.polioeradication.org); Indian Expert Advisory Group (IEAG). (2012). *Twenty Fourth Meeting of the India Expert Advisory Group for Polio Eradication*, Delhi, India 15-16 March. (Retrieved from www.polioeradication.org); Indian Expert Advisory Group (IEAG). (2013). *Twenty-Fifth Meeting of the India Expert Advisory Group for Polio Eradication*, Delhi, India 3 May. (Retrieved from www.polioeradication.org)

[663] Interview

to strengthen the routine immunization and overall health systems of the program in the country.

6. CONTEXTUAL CONTESTATIONS OF THE POLIO PROGRAM

Epidemiological And Ethical Debates

In India, polio policy was conceptualized and implemented within the environment of epidemiological and ethical contestations raised on the overall program and its processes. Throughout the implementation of the polio program, repetitive and extensive discussions were done within the communities of public health experts, academicians, and scientists questioning the overall relevance of the program and effectiveness of program strategies, particularly in resolving the problem of endemic states and hostile press environment negatively impacted the program progress. Despite intense contestation, doubts and suspicion were raised about the overall polio program strategies, particularly in highly endemic reservoir areas of western UP. In their meetings, the government of India and IEAG repeatedly reassured India's population that the program strategies were adequate to achieve the final interruption of poliovirus in endemic areas.

Debates on epidemiological and ethical concerns about the polio program have developed since the program's inception in India among public health experts and activists. Serious concerns and debates were raised on the need for a polio eradication program in developing countries and conceptualizing the polio program in India, neglecting severe ethical concerns in planning and implementing the program.

The primary concern was centred on the relevance of the polio program in India and the safety and effectiveness of OPV in reducing the number of polio cases. Polio initiative in endemic countries was considered to be influenced by industrialized countries. Endemic countries were required to eradicate the polio virus through mass immunization campaigns overlooking other important health priorities. The program negatively affected the country's

health system and misrepresented epidemiological facts. The contextual epidemiological limitations of OPV, environmental risk factors, poor efficacy of oral polio, and harmful effects of OPV were ignored mainly in program planning and implementation. Instead, the program was pushed by donors in the country despite its repeated failure and harmful effects as a political responsibility of endemic countries toward polio-free areas.

Polio eradication was ethically and epidemiologically questioned because of confusion in the use of eradication and elimination terms for measuring its policy outcome, misrepresentation of epidemiological data, limitation of a surveillance system with a focus on only AFP poliovirus cases, poor efficacy of OPV in specific ecological and epidemiological context, administration of more than recommended doses of OPV to children, reoccurrence of polio cases, iatrogenic risks of OPV-based campaign, no policy of informed consent from parents of vaccinated children, lack of adequate dissemination of epidemiological information among community-related to limitations of OPV in protecting against polio infection and its harmful risks, no policy to compensate paralysis caused to children from harms of vaccine-associated paralytic polio or vaccine-derived paralytic polio caused by OPV, and inability in contributing to the development of sustainable health systems in developing countries. These epidemiological and ethical dimensions of conceptualization and implementation of the polio eradication program in India, as pointed out by larger interest groups outside of government, are discussed in detail in the below sections.

6.1 GPEI and its Epidemiological Need in India?

The goal of polio eradication could not be achieved only by determining and promoting the eradication program's biological, economic, and social efficacy and OPV in the endemic areas. Mass immunization programmes with vaccines as a central strategy have biological,

epidemiological, and social limitations. Immunization programs entirely dependent on vaccines to wipe a disease are insufficient, particularly in developing countries with insufficient health systems and a high incidence of other infectious diseases.

In the Indian context, the government became a signatory of the polio eradication program and started a mass immunization campaign in the country in 1995, but the journey of implementing the polio eradication program met with several obstacles. The deadline to eradicate polio got missed several times in the country, along with the poor efficacy of OPV, resulting in frequent outbreaks of the polio epidemic in the northern states of Uttar Pradesh and Bihar. The polio eradication program in endemic countries received unprecedented support from the state governments, developed countries and wealthy donors. However, public health professionals and health activists around the world raised many concerns about the need for polio eradication programs in developing countries since the beginning of the program. The poor performance of the polio eradication program in developing countries strengthens these concerns and raises questions about the need for the program, the central strategy used in the program and ethical concerns regarding the promotion and implementation of OPV.[664] At one point in the history of the polio eradication program in India, it was considered a failure in the country by epidemiologists and public health experts.[665]

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[664] Sathyamala, C., Mittal, O., Dasgupta, R., and Priya, R. (2005). Polio Eradication Initiative in India: Deconstructing the GPEI. *International Journal of Health Services*, 35(2), 361-83; John, T.J. (2006). Polio Eradication: A National Commission Required. *Economic and Political Weekly,* 23,5229- 5234; Paul, Y, & Dawson, A. (2005). Some Ethical Issues Arising from Polio Eradication Programmes in India. *Bioethics*, 19(4), 393-406; Paul, Y. (2006). Polio Eradication Programme: A Failure. *Economic and Political Weekly,* 4, 4538-4540; Paul, Y. (2005). Polio eradication programme: Some Ethical Issues. *Indian Journal of Medical Ethics*, II(4).

[665] Sathyamala, C., Mittal, O., Dasgupta, R., and Priya, R. (2005). Polio Eradication Initiative in India: Deconstructing the GPEI. *International Journal of Health Services*, 35(2), 361-83; Polio Eradication Programme: A Failure. *Economic and Political Weekly*, 4, 4538- 4540; Banerji, D., Deohar, N.S., Qadeer, I. Sathyamala, C., Mittal, O., Priya, R., et al. (2008). *Memorandum on Pulse Polio: Submitted to the World Health Organization, UNICEF, and the Government of India, on 7 April 2004, The World Health Day.* (Retrieved from http://aidanindia.worpress.com/2008/08/12/memorudum-on-pulse-polio/)

Public health professionals strongly resisted the program in India by sending a memorandum on the pulse polio program to the World Health Organization, UNICEF and the Government of India in 2004.[666] The memorandum put forth the concern that the repeated failure of the eradication campaign in the country is not a consequence of poor implementation or lack of political will but due to fundamental flaws in the strategy of the polio initiative itself.

"We contend that the goal of GPEI was flawed from the time of its conception and is unlikely to achieve its stated objectives this year or in the coming years" pp.1[667]

The memorandum claimed that the government of India was misled by the WHO and scientific organizations, who were aware of the gaps in the core strategy of the global polio initiative.[668]

Memorandum put forth the concern that the repeated failure of the eradication campaign in the country is not a consequence of poor implementation or lack of political will but due to fundamental flaws in the strategy of the polio initiative itself. The primary ethical concerns globally and Indian public health experts raised was the need to promote a polio eradication program in developing countries. The central discourse on this theme was that the polio eradication program in developing countries is influenced by industrialized countries that have already eliminated or controlled polio.[669]

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[666] Banerji, D., Deohar, N.S., Qadeer, I. Sathyamala, C., Mittal, O., Priya, R., et al. (2008). *Memorandum on Pulse Polio: Submitted to the World Health Organization, UNICEF, and the Government of India, on 7 April 2004, The World Health Day.* (Retrieved from http://aidanindia.worpress.com/2008/08/12/memorudum-on-pulse-polio/)

[667] Banerji, D., Deohar, N.S., Qadeer, I. Sathyamala, C., Mittal, O., Priya, R., et al. (2008). *Memorandum on Pulse Polio: Submitted to the World Health Organization, UNICEF, and the Government of India, on 7 April 2004, The World Health Day.* (Retrieved from http://aidanindia.worpress.com/2008/08/12/memorudum-on-pulse-polio/)

[668] Banerji, D., Deohar, N.S., Qadeer, I. Sathyamala, C., Mittal, O., Priya, R., et al. (2008). *Memorandum on Pulse Polio: Submitted to the World Health Organization, UNICEF, and the Government of India, on 7 April 2004, The World Health Day.* (Retrieved from http://aidanindia.worpress.com/2008/08/12/memorudum-on-pulse-polio/)

[669] Banerji, D., Deohar, N.S., Qadeer, I. Sathyamala, C., Mittal, O., Priya, R., et al. (2008). *Memorandum on Pulse Polio: Submitted to the World Health Organization, UNICEF, and the Government of India, on 7 April*

The program was not high on the public health priority list of developing countries with other health problems such as pneumonia, malaria, diarrhoea, measles, and malnutrition.[670]

The final decision to start a mass polio vaccination campaign in developed countries was based on the cost of protection provided to the population and its social efficacy in avoiding losses incurred on the individuals. However, in endemic- countries, the polio eradication initiative was pushed on to the governments by developed countries because of concerns about poliovirus being exported from endemic countries to polio-free areas.[671]

In India, the program was not based on epidemiological criteria. Instead, reasons for selection were based on the feasibility of eradicating the disease.[672] Paralytic poliomyelitis was not a major reported problem before the launch of GPEI in the country. The WHO declared paralytic poliomyelitis a significant public health problem based on estimated figures worldwide rather than on reported. The WHO is being critiqued for overestimating the figures 10-fold, increasing the polio cases from 35000 to 350,000 in 1988 when the global polio eradication program was launched.[673]

Thus, the polio program was promoted high in priority in endemic countries as a global political responsibility. The negative effect on poorer countries was that governments were pressured to put back their actions on priority health problems and to divert their limited

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2004, The World Health Day. (Retrieved from http://aidanindia.worpress.com/2008/08/12/memorudum-on-pulse-polio/); Sathyamala, C., Mittal, O., Dasgupta, R., and Priya, R. (2005). Polio Eradication Initiative in India: Deconstructing the GPEI. *International Journal of Health Services*, 35(2), 361-83; Taylor, E.C, Cutts, F, & Taylor, E.M. (1997). Ethical Dilemmas in Current Planning for Polio Eradication, *American Journal of Public Health*, 87(6),922-925.

[670] World Bank. (1993). *World Development Report 1993: Investing in Health*. New York: Oxford University Press. (Retrieved from www.who.int)

[671] Sathyamala, C., Mittal, O., Dasgupta, R., and Priya, R. (2005). Polio Eradication Initiative in India: Deconstructing the GPEI. *International Journal of Health Services*, 35(2), 361-83.

[672] John, T.J. (2004 April 03). Final push for polio eradication. *The HINDU (Opinion Section).*

[673] Sathyamala, C., Mittal, O., Dasgupta, R., and Priya, R. (2005). Polio Eradication Initiative in India: Deconstructing the GPEI. *International Journal of Health Services*, 35(2), 361-83.

resources for a globally set goal.[674] This undermines developing countries' capability to make their own rational health decisions and puts international political pressure on endemic countries to eradicate polio.

6.2 Eradication or Elimination of Poliovirus

The WHA resolution set the goal of eradicating polio, but even at the Global Polio Eradication Initiative (GPEI) conceptualization, there was not a clear understanding of the word '*eradication'* and its difference from *elimination*. The simple difference in the definition of eradication and elimination is that in eradication, intervention measures are no longer needed as there is a complete absence of a specific agent causing the disease, expect in laboratories. In contrast, elimination is only interruption of virus transmission as continued measures are required even after zero incidences of a disease-causing agent. Much confusion in the use of eradication terms and misrepresentation of accurate epidemiological data can be seen in the varied definition of polio eradication in different texts related to polio eradication initiatives.

The confusion among the world health community can be seen in the Dahlem Workshop, 1997. The Dahlem Workshop defined the eradication as -

"Permanent reduction to zero of the worldwide incidence of infection caused by a specific agent as a result of deliberate efforts; intervention measures are no longer needed" pp.6 [675]

But the workshop gave poliomyelitis along with measles as an example of elimination of infectious diseases as -

[674] Taylor, E.C, Cutts, F, & Taylor, E.M. (1997). Ethical Dilemmas in Current Planning for Polio Eradication, *American Journal of Public Health*, 87(6),922-925.
[675] Dowdle, R.W. (1998). The principles of disease elimination and eradication. *Bulletin of the world health organization*, 76(2),22-25.

"Reduction to zero of the worldwide incidence of infection caused by a specific agent in a defined geographical area due to deliberate efforts. Continuous measurements to prevent re-establishment of transmission are required. Example: - measles and poliomyelitis" pp.6[676]

Similar confusion could be seen in Global Commission for the Certification of the Eradication of Poliomyelitis which defines the main criteria of eradication as the absence of circulation of wild polioviruses in all WHO regions for at least three years in the presence of high-quality, certification-standard surveillance.[677] The second criterion is the containment of all poliovirus's stocks in laboratories.[678]

The definition of eradication as the absence of wild poliovirus infection in a given geographical area used by WHO does not include the absence of vaccine-induced poliomyelitis risk associated with OPV use. The OPV contains a live vaccine virus and can cause poliovirus-induced AFP cases or vaccine virus-induced; thus, the eradication definition is considered incomplete by Indian and world public health experts as it does not include the absence of vaccine-induced poliomyelitis.[679]

Similar confusion could be seen in an operational guide for the polio eradication program in India, which define eradication, where no clinical poliomyelitis cases related to poliovirus are reported, and there is an absence of transmission of wild poliovirus within the environment.[680]

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[676] Dowdle, R.W. (1998). The principles of disease elimination and eradication. *Bulletin of the world health organization*, 76(2),22-25.
[677] World Health Organization. (1998). *Report of the Second Meeting of the Global Commission for the Certification of the Eradication of Poliomyelitis*. Geneva. (Retrieved from www.who.int)
[678] World Health Organization. (2013). *WHO Global action plan for laboratory containment of wild polioviruses*, 2nd ed. Geneva. (Retrieved from www.polioeradication.org)
[679]Sathyamala, C., Mittal, O., Dasgupta, R., and Priya, R. (2005). Polio Eradication Initiative in India: Deconstructing the GPEI. *International Journal of Health Services*, 35(2), 361-83.
[680] Child Health Division, Department of Family Welfare (2003*). Pulse Polio Immunization in India: Operational Guide 2003–04.* Government of India. New Delhi. (Retrieved from www.mohfw.gov.in)

The WHO Polio Eradication & Endgame Strategic Plan 2013-2018 also states that interruption of wild poliovirus by the end of 2014 is one of the four primary objectives, along with continued intervention measures.[681] Thus the end game eradication strategy is only an elimination strategy and not an eradication strategy.

All the above definitions given by different policy-related documents show confusion on the definition of eradication as interruption of transmission of polio virus or absence of it. Consequently, both the eradication and elimination words were used interchangeably in defining the goals of the polio program, its implementation, and the measurement of polio eradication program outcomes in the endemic countries.

6.3 Mis-Representation of Epidemiological Facts

Concerns were raised in India on the change in the case definition of reporting polio cases resulting in an underestimation of correct polio cases in the country. The definition of polio cases changed thrice in the country since the beginning of the program.[682] It is recognized among public health experts that much of the OPV-based reduction in polio cases attributed in the country by WHO is because of changes made in the criteria of recording the polio cases.[683]

Change in case definition also raised questions on the overall effectiveness of OPV in reducing the number of paralytic polio cases in India and immunity produced against the

[681] World Health Organization. (2013). *Polio Eradication &Endgame Strategic Plan 2013-2018*. WHO, France. (Retrieved from www.polioeradication.org)
[682] Sathyamala, C., Mittal, O., Dasgupta, R., and Priya, R. (2005). Polio Eradication Initiative in India: Deconstructing the GPEI. *International Journal of Health Services*, 35(2), 361-83.
[683] Sathyamala, C., Mittal, O., Dasgupta, R., and Priya, R. (2005). Polio Eradication Initiative in India: Deconstructing the GPEI. *International Journal of Health Services*, 35(2), 361-83; Paul, Y, & Dawson, A. (2005). Some Ethical Issues Arising from Polio Eradication Programmes in India. *Bioethics*, 19(4), 393-406.

poliovirus in children after receiving three doses or more doses of OPV. In India, no large-scale serological studies were conducted to determine the antibody response to OPV.[684]

It is also recognized that children receiving three or more doses of OPV in India may not have developed polio because of improvements in hygiene and sanitation and exposure to wild poliovirus, which may have reduced chances of exposure and induced immunity to poliovirus among children.[685]

Another primary concern raised on the method of surveillance of the circulation of polio cases in the community by WHO and the misrepresentation of epidemiological facts. The clinical profile of poliovirus shows that poliovirus infection is highly variable. A large number (72 per cent) of polio infections are asymptomatic, and infections go unrecognized.[686]

The severity of polio infection is determined based on clinical diagnosis. In 24 per cent of cases, polio infection in children's is a very mild or non-specific illness without clinical or laboratory evidence. Such clinically presented cases are abortive, and poliomyelitis is recoverable in less than a week.[687]

Thus, poliovirus silently circulates in the community without being recognized. The infection causes 1- 0.5 per cent or less of total polio infections and causes 2 to 10 per cent of

[684] Paul, Y, & Dawson, A. (2005). Some Ethical Issues Arising from Polio Eradication Programmes in India. *Bioethics*, 19(4), 393-406.
[685] Paul, Y, & Dawson, A. (2005). Some Ethical Issues Arising from Polio Eradication Programmes in India. *Bioethics*, 19(4), 393-406.
[686] Centers for Disease Control & Prevention (CDC). (2015). *Poliomyelitis*. Centers for Disease Control and Prevention Epidemiology and Prevention of Vaccine-Preventable Diseases, 13th Ed, 297-310 (Retrieved from www.cdc.gov)
[687] Centers for Disease Control & Prevention (CDC). (2015). *Poliomyelitis*. Centers for Disease Control and Prevention Epidemiology and Prevention of Vaccine-Preventable Diseases, 13th Ed, 297-310 (Retrieved from www.cdc.gov)

paralytic polio cases in the community.[688] In India, the infection usually transmits through the faecal-oral route because of inadequate sanitation.

In India, the National Polio Surveillance Program (NPSP) was launched in 1997 to monitor and report the number of polio cases in the country. The NPSP uses only acute flaccid paralysis (AFP) cases as surveillance markers to assess the circulation of poliovirus in the community. AFP is defined as acute onset of flaccid paralysis in any child under 15 years for which no apparent cause is found or paralytic illness in a person of any age in which polio is suspected. The AFP cases are laboratory-confirmed wild poliovirus cases.[689]

By this definition of AFP used in the country, polio cases consist of less than 1 per cent of all infections in children due to wild poliovirus resulting in flaccid paralysis.[690]

Many children with paralytic polio recover completely without developing permanent paralysis.[691] It is estimated that NPSP excludes around 100 to 1000 clinically in-apparent infections not showing paralysis for every paralytic polio case.[692]

The NPSP excluded a large number of infections due to poliovirus causing subclinical infections, case fatalities not reported as AFP cases and not confirmed, and not reported wild polio-AFP cases. The virus silently circulates in the community, and the WHO claims that the

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[688] Sathyamala, C., Mittal, O., Dasgupta, R., and Priya, R. (2005). Polio Eradication Initiative in India: Deconstructing the GPEI. *International Journal of Health Services*, 35(2), 361-83.
[689] Child Health Division, Department of Family Welfare. (2000). *Surveillance of Acute Flaccid Paralysis, Field Guide, Ed. 2.* Government of India, New Delhi. (Retrieved from www.mohfw.gov.in)
[690] Centers for Disease Control & Prevention (CDC). (2015). *Poliomyelitis*. Centers for Disease Control and Prevention Epidemiology and Prevention of Vaccine-Preventable Diseases, 13th Ed, 297-310 (Retrieved from www.cdc.gov); Sathyamala, C., Mittal, O., Dasgupta, R., and Priya, R. (2005). Polio Eradication Initiative in India: Deconstructing the GPEI. *International Journal of Health Services*, 35(2), 361-83.
[691] Centers for Disease Control & Prevention (CDC). (2015). *Poliomyelitis*. Centers for Disease Control and Prevention Epidemiology and Prevention of Vaccine-Preventable Diseases, 13th Ed, 297-310 (Retrieved from www.cdc.gov)
[692] Child Health Division, Department of Family Welfare. (2000). *Surveillance of Acute Flaccid Paralysis, Field Guide, Ed. 2.* Government of India, New Delhi. (Retrieved from www.mohfw.gov.in)

absence of zero polio cases in the community is only an assumption and does not provide accurate evidence on the transmission of wild poliovirus in the region. [693]

The surveillance method used to measure the eradication goal as a complete absence of wild poliovirus from the environment is limited as it excludes laboratory, not confirmed AFP polio cases circulating in the environment. Thus, the definition of eradication is limited to the interruption of poliovirus or elimination of it.[694] The interest of WHO in only laboratory-confirmed AFP cases as the single measure of circulating wild poliovirus in the community had resulted in the misrepresentation of epidemiological processes. The GPEI measures a single case of polio in the community as indicative of the wild polio virus transmission. Thus, the limitation of the surveillance system and circulation of poliovirus varies silently in communities, making the complete eradication of wild poliovirus difficult in endemic countries as even one reported case can nullify the certification process.[695]

6.4 Negative Implication of GPEI in Endemic Countries

A primary ethical concern raised on the polio eradication campaign was that it does not contribute to developing sustainable health systems in poorer countries. It has been experienced that progress to eradication is achievable only in countries with well-established and sustainable health systems.[696]

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[693] Sathyamala, C., Mittal, O., Dasgupta, R., and Priya, R. (2005). Polio Eradication Initiative in India: Deconstructing the GPEI. *International Journal of Health Services*, 35(2), 361-83.
[694] Sathyamala, C., Mittal, O., Dasgupta, R., and Priya, R. (2005). Polio Eradication Initiative in India: Deconstructing the GPEI. *International Journal of Health Services*, 35(2), 361-83.
[695] Banerji, D., Deohar, N.S., Qadeer, I. Sathyamala, C., Mittal, O., Priya, R., et al. (2008). *Memorandum on Pulse Polio: Submitted to the World Health Organization, UNICEF, and the Government of India, on 7 April 2004, The World Health Day.* (Retrieved from http://aidanindia.worpress.com/2008/08/12/memorudum-on-pulse-polio/)
[696] World Health Organization. (1995). *Report of the 1st meeting of the Global Commission for the Certification of the Eradication of Poliomyelitis. Geneva*. WHO document WHO/EPI/GEN/95.6. (Retrieved from www.who.int)

The twin objective promised by World Health Assembly in 1988 was polio eradication along with developing sustainable health systems and strengthening national immunization programmes.[697] However, the polio eradication program could not go beyond the narrow goal of eradication.

The benefit-cost analysis of pushing eradication initiatives in endemic countries was high for industrialized countries as it provides annual savings on the cost to sustain eradication and surveillance costs in developed countries. From developing countries' perspectives, the benefits of eradicating polio were less as it involves risks of diverting focus from other infectious disease programs and health system strengthening activities.[698]

The polio eradication initiative attracted significant funding from international organizations and bilateral donors. However, the donor-driven funding for polio eradication was targeted only for direct incremental cost on polio vaccine procurement, particularly for NIDs, international technical advisors, cold chain equipment, and laboratories for surveillance. The remaining cost of the polio campaign on in-kind contributions such as voluntary work, inter-sectoral activities, advocacy efforts, indirect cost on health workers' salaries, time spent on planning and implementation and several others were endured by governments of developing countries.[699]

Furthermore, the campaign mode of implementing the polio program affected the routine immunization program in India, resulting in a resurgence of other vaccine-preventable

[697] World Health Organization. (1988). *Forty-First World Health Assembly, Global eradication of poliomyelitis by the year 2000*, Geneva, WHA41.28. .(Retrieved from www.who.int)
[698] Taylor, E.C, Cutts, F, & Taylor, E.M. (1997). Ethical Dilemmas in Current Planning for Polio Eradication, *American Journal of Public Health*, 87(6),922-925.
[699] Taylor, E.C, Cutts, F, & Taylor, E.M. (1997). Ethical Dilemmas in Current Planning for Polio Eradication, *American Journal of Public Health*, 87(6),922-925.

diseases and other infectious diseases in the country.[700] Thus, estimates of actual investments in the program and the adverse effects of the polio program were not calculated, and its costs were more significant for developing countries.

The benefits of eradicating polio in the developed world were extrapolated to the poorest countries. It has been experienced that progress to polio eradication is achievable only in countries with well-established and sustainable health systems, with strong leadership at central and district levels, a well-organized infrastructure, local ownership, and decision making.[701]

It was considered-

"shortsighted for donors to use their considerable influence to promote polio eradication if this delays or diverts long-term investment by poor countries in sustainable health systems" pp. 924[702]

The donor and rich countries lack a strong commitment and vision for investing the benefits of polio eradication for building sustainable health services in underdeveloped and developing countries which could ensure long-term benefits to these countries in reducing the spread of diseases and other potential health benefits. Thus, the program raised ethical implications, resulting in an imbalance between local priorities and global goals.

Ethical concerns were raised about administering more than the recommended three doses of OPV in India. In developed countries, three doses of OPV were recommended for wiping the polio virus from the regions. However, in developing countries such as India, there

[700] Sathyamala, C., Mittal, O., Dasgupta, R., and Priya, R. (2005). Polio Eradication Initiative in India: Deconstructing the GPEI. *International Journal of Health Services*, 35(2), 361-83.
[701] Taylor, E.C, Cutts, F, & Taylor, E.M. (1997). Ethical Dilemmas in Current Planning for Polio Eradication, *American Journal of Public Health*, 87(6),922-925.
[702] Taylor, E.C, Cutts, F, & Taylor, E.M. (1997). Ethical Dilemmas in Current Planning for Polio Eradication, *American Journal of Public Health*, 87(6),922-925.

were no fixed criteria set by the epidemiologist on an exact number of doses of OPV to be given to individuals to ensure protection against the wild polio virus. In India, under the campaign mode of the polio eradication program, each child in the first five years of age received more than recommended three doses of OPV.[703] Apart from receiving three doses of OPV in infancy in routine immunization, a child in India received ten or more doses through National Immunization Days (NIDs) and Sub-National Immunization Days (SNIDs) and mop-up campaigns. The number of doses exceeded more than 18 doses in some 'high risk' states.[704] In some high-risk states, the number of doses exceeded more than 25 in the first five years of age.[705]

The WHO justified the excessive doses given to children based on criteria that completely immunized children can harbour and transmit poliovirus. Thus, it is required to immunize all children during mass immunization campaigns.[706] OPV is a live attenuated vaccine and can have serious adverse health consequences on children receiving it. Thus, the lack of adequate information on the epidemiological need for an increase in the number of doses in the country and its varied number from region to region raised severe ethical concerns for Indian children.

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[703] Sathyamala, C., Mittal, O., Dasgupta, R., and Priya, R. (2005). Polio Eradication Initiative in India: Deconstructing the GPEI. *International Journal of Health Services*, 35(2), 361-83.

[704] Taylor, E.C, Cutts, F, & Taylor, E.M. (1997). Ethical Dilemmas in Current Planning for Polio Eradication, *American Journal of Public Health*, 87(6),922-925.

[705] Banerji, D., Deohar, N.S., Qadeer, I. Sathyamala, C., Mittal, O., Priya, R., et al. (2008). *Memorandum on Pulse Polio: Submitted to the World Health Organization, UNICEF, and the Government of India, on 7 April 2004, The World Health Day.* (Retrieved from http://aidanindia.worpress.com/2008/08/12/memorudum-on-pulse-polio/)

[706] Taylor, E.C, Cutts, F, & Taylor, E.M. (1997). Ethical Dilemmas in Current Planning for Polio Eradication, *American Journal of Public Health*, 87(6),922-925.

6.5 Social Mobilization Strategies & Ethical Concerns

Apart from four key strategies, social mobilization strategies were implemented as an essential contextual strategy for the polio eradication campaign in India tailored to the contextual needs of northern regions in Bihar and the western states of Uttar Pradesh (UP).[707] Uttar Pradesh and Bihar were epidemiologically reservoirs for transmission of WPV, especially in urban and peri-urban areas of western UP.[708]

Many social-religious and cultural factors were associated with the large number of polio cases reported from western UP.[709] This moved the attention of policy experts to identify the factors responsible for a large number of the outbreak of polio cases, particularly in western UP.

Social resistance to OPV formed the cornerstone of all the other epidemiological, environmental and vaccine-related factors responsible for many unvaccinated polio cases in

[707] John, T.J., & Vashishtha, M.V. (2013). Eradicating poliomyelitis: India's journey from hyperendemic to polio-free status. *Indian Journal of Medical Research*, 137,881-894; Grassly, N.C., Fraser, C., Wenger, J., Deshpande, J.M., Sutter, R.W., Heymann, D.L., et al. (2006). New strategies for the elimination of polio from India. *Science.*314, 1150-3; Chaturvedi et al. (2009). Deconstructing Social Resistance to Pulse Polio Campaign in Two North Indian Districts. *Indian Pediatrics,* 974(46); United Nations Children's Fund (UNICEF). (2013). *Eradicating polio getting to zero resistance*. UNICEF, Lucknow. (Retrieved from www.unicef.org)

[708] Dasgupta R, Chaturvedi S, Adhish S.V, Ganguly K.K, Rai S, Sushant, L, & Arora, K.N. (2008) Social Determinants and Polio 'Endgame': A Qualitative Study in High-Risk Districts of India. *Indian Pediatrics*, 359(45); Chaturvedi et al. (2009). Deconstructing Social Resistance to Pulse Polio Campaign in Two North Indian Districts. *Indian Pediatrics,* 974(46).

[709] Chaturvedi et al. (2009). Deconstructing Social Resistance to Pulse Polio Campaign in Two North Indian Districts. *Indian Pediatrics,* 974(46); United Nations Children's Fund (UNICEF). (2013). *Eradicating polio getting to zero resistance*. UNICEF, Lucknow. (Retrieved from www.unicef.org); Ansari, A.M., Khan, Z. & Khan, M. I. (2007). Reducing resistance against polio drops. *The Journal of the Royal Society for the Promotion of Health*, 127(6), 276-279; Ansari et al.(2013). Role of social mobilization in tackling the resistance to polio eradication program in underserved communities of Aligarh, India. *South-East Asia Journal of Public Health*, 3(2), 23-29.

western districts of UP.[710] However, resistance was sporadic and transient.[711] Resistance to OPV and social mobilization activities was confined to India, and parts of Nigeria and Pakistan also reported similar resistance.

Such social resistance to vaccines was not new in the history of public health mass vaccination campaigns. Similar patterns of social resistance to the smallpox eradication program (1972-1977) and mass tuberculosis BCG vaccination (1955-56) were reported.[712] However, the critical learnings such as building trust and confidence among communities about the immunization campaign were not taken into account while framing the policy for the polio eradication campaign.

General fatigue was also reported in the community because of intensified repeated rounds of polio immunization.[713] These intensification OPV rounds were done because of the difficulty of reaching and tracking every child in routine immunization and later in the program because of changes in polio vaccination policy from trivalent to monovalent type 1 & 2

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[710] Chaturvedi et al. (2009). Deconstructing Social Resistance to Pulse Polio Campaign in Two North Indian Districts. *Indian Pediatrics,* 974(46); Dasgupta R, Chaturvedi S, Adhish S.V, Ganguly K.K, Rai S, Sushant, L, & Arora, K.N. (2008) Social Determinants and Polio 'Endgame': A Qualitative Study in High-Risk Districts of India. *Indian Pediatrics*, 359(45); United Nations Children's Fund (UNICEF). (2013). *Eradicating polio getting to zero resistance.* UNICEF, Lucknow. (Retrieved from www.unicef.org); Paul, Y. (2007). What needs to be done for polio eradication in India? *Vaccine*, 25, 6431–6436; Grassly, N.C., Fraser, C., Wenger, J., Deshpande, J.M., Sutter, R.W., Heymann, D.L., et al. (2006). New strategies for the elimination of polio from India. *Science*.314, 1150-3; Grassly et al. (2007). Protective efficacy of a monovalent oral type 1 poliovirus vaccine: a case-control study. *Lancet,* 369, 1356-62

[711] Chaturvedi et al. (2009). Deconstructing Social Resistance to Pulse Polio Campaign in Two North Indian Districts. *Indian Pediatrics,* 974(46).

[712] Bhattacharya S. (2006). *Expunging Variola: The Control and Eradication of Smallpox in India 1947-1977.* New Delhi: Orient Longman; Mcmillen, W.C. & Brimnes, N. (2010).Medical Modernization and Medical Nationalism: Resistance to Mass Tuberculosis Vaccination in Postcolonial India, 1948–1955.*Comparative Studies in Society and History*, 52(1),180–209.

[713] Chaturvedi et al. (2009). Deconstructing Social Resistance to Pulse Polio Campaign in Two North Indian Districts. *Indian Pediatrics,* 974(46); Dasgupta R, Chaturvedi S, Adhish S.V, Ganguly K.K, Rai S, Sushant, L, & Arora, K.N. (2008) Social Determinants and Polio 'Endgame': A Qualitative Study in High-Risk Districts of India. *Indian Pediatrics*, 359(45); United Nations Children's Fund (UNICEF). (2013). *Eradicating polio getting to zero resistance.* UNICEF, Lucknow. (Retrieved from www.unicef.org)

vaccines and later bivalent to improve the effectiveness of OPV towards the end phases of the program implementation.

The community and parents were unaware of changes within the program and the need for repeated polio rounds because of vaccine failure.[714] Also, because of vaccine failure and VAPP cases, there was an unmistakable impression among the communities that children develop polio even after taking the vaccine and even after taking many doses of the vaccine. So, it was natural for parents to be cautious and suspicious about the vaccine and the health workers' motives for the polio campaign. There were also incidents of adverse effects such as deaths of children when OPV was given to sick children. The death of children was mainly attributed to OPV by parents and negatively impacted the PPI campaign and communities' perception of OPV.

Reasons for vaccine-related rumours and social resistance to oral polio vaccination (OPV) were primarily reported from the socially economically marginalized population of the districts of UP, largely deprived of basic amenities, health infrastructure and other essential services. Such populations were at increased environmental risk of polio infection.[715] The effort of the government to vaccinate their children from one disease aroused misconceptions and suspicion among people within the context of neglect of other diseases, unresponsive,

[714] Chaturvedi et al. (2009). Deconstructing Social Resistance to Pulse Polio Campaign in Two North Indian Districts. *Indian Pediatrics,* 974(46).

[715] Chaturvedi et al. (2009). Deconstructing Social Resistance to Pulse Polio Campaign in Two North Indian Districts. *Indian Pediatrics,* 974(46); Dasgupta R, Chaturvedi S, Adhish S.V, Ganguly K.K, Rai S, Sushant, L, & Arora, K.N. (2008) Social Determinants and Polio 'Endgame': A Qualitative Study in High-Risk Districts of India. *Indian Pediatrics*, 359(45); United Nations Children's Fund (UNICEF). (2013). *Eradicating polio getting to zero resistance*. UNICEF, Lucknow. (Retrieved from www.unicef.org); Ansari, A.M., Khan, Z. & Khan, M. I. (2007). Reducing resistance against polio drops. *The Journal of the Royal Society for the Promotion of Health*, 127(6), 276-279;Ansari et al.(2013). Role of social mobilization in tackling the resistance to polio eradication program in underserved communities of Aligarh, India. *South-East Asia Journal of Public Health*, 3(2), 23-29.

ineffective primary health care services, and dismal living conditions in which the population was residing.[716]

To overcome resistance to OPV in the communities deprived of health and development activities, building trust and confidence for OPV was crucial for improving polio immunization coverage. Thus, social resistance among communities was one a reason for the high prevalence of polio cases in UP, and social mobilization strategies became an essential component of the PPI to address the growing resistance to the PPI.

The primary purpose of social mobilization activities was to implement innovative communication strategies to counter various myths and misconceptions and change people's attitudes, opinions and behaviours towards OPV.[717]

It is claimed by international organizations that the success of the social mobilization strategy reduced the resistance and improved the immunization coverage of polio vaccination.[718]

However, severe ethical concerns were raised on the nature of social mobilization strategies used and the misrepresentation of epidemiological facts to community-related

[716] Dasgupta, R. (2009). Serious Messages Behind VDPV Cases in India. *Indian Journal of Pediatrics*, 46; Chaturvedi et al. (2009). Deconstructing Social Resistance to Pulse Polio Campaign in Two North Indian Districts. *Indian Pediatrics,* 974(46);United Nations Children's Fund (UNICEF). (2013). *Eradicating polio getting to zero resistance*. UNICEF, Lucknow. (Retrieved from www.unicef.org); Ansari, A.M., Khan, Z. & Khan, M. I. (2007). Reducing resistance against polio drops. *The Journal of the Royal Society for the Promotion of Health*, 127(6), 276-279;Ansari et al.(2013). Role of social mobilization in tackling the resistance to polio eradication program in underserved communities of Aligarh, India. *South-East Asia Journal of Public Health*, 3(2), 23-29.

[717] United Nations Children's Fund (UNICEF). (2013). *Eradicating polio getting to zero resistance*. UNICEF, Lucknow. (Retrieved from www.unicef.org); Obregón R, Waisbord S. (2010). The complexity of social mobilization in health communication: Top-down and bottom-up experiences in polio eradication. *Journal of Health Communication: International Perspectives,*15, 25–47; Chaturvedi, G. (2008). *The Vital Drop: Communication for Polio Eradication in India*. Sage Publications India.

[718] United Nations Children's Fund (UNICEF). (2013). *Eradicating polio getting to zero resistance*. UNICEF, Lucknow. (Retrieved from www.unicef.org)

program implementation in India.[719] Social mobilization strategies were exclusively top-down informative communication strategies. In this top-down approach, communities were informed and directed on appropriate actions for achieving the polio eradication goal. Thus, community participation was limited, resulting in conflict between local priorities of integrated health services and polio eradication goals.[720]

The social mobilization strategies and materials used in the polio eradication program did not inform parents about the limitations of OPV and its iatrogenic harmful effects on children. Instead, significance was given to advocating OPV among the community.[721] The parents were not informed about epidemiological information related to the program, such as the limitation of OPV in protecting against polio infection in high-risk areas, the risk of developing VAPP, the high risk of VAPP among immuno-compromised children, and the risk of intramuscular injections.[722]

Informed consent, which forms the cornerstone of ethics in implementing mass vaccination campaigns, was undermined in the polio eradication program in India. No attempts were made in the polio eradication program to take informed consent from parents of

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[719]Sathyamala, C., Mittal, O., Dasgupta, R., and Priya, R. (2005). Polio Eradication Initiative in India: Deconstructing the GPEI. *International Journal of Health Services*, 35(2), 361-83; Banerji, D., Deohar, N.S., Qadeer, I. Sathyamala, C., Mittal, O., Priya, R., et al. (2008). *Memorandum on Pulse Polio: Submitted to the World Health Organization, UNICEF, and the Government of India, on 7 April 2004, The World Health Day.* (Retrieved from http://aidanindia.worpress.com/2008/08/12/memorudum-on-pulse-polio/); Paul, Y. (2005). Polio eradication programme: Some Ethical Issues. *Indian Journal of Medical Ethics*, II(4); Paul, Y, & Dawson, A. (2005). Some Ethical Issues Arising from Polio Eradication Programmes in India. *Bioethics*, 19(4), 393-406; Rafael, O. & Silvio, W. (2010) The Complexity of Social Mobilization in Health Communication: Top-Down and Bottom-Up Experiences in Polio Eradication. *Journal of Health Communication*, 15(1), 25-47.

[720] Taylor, E.C, Cutts, F, & Taylor, E.M. (1997). Ethical Dilemmas in Current Planning for Polio Eradication, *American Journal of Public Health*, 87(6),922-925; Rafael, O. & Silvio, W. (2010) The Complexity of Social Mobilization in Health Communication: Top-Down and Bottom-Up Experiences in Polio Eradication. *Journal of Health Communication*, 15(1), 25-47.

[721]Paul, Y, & Dawson, A. (2005). Some Ethical Issues Arising from Polio Eradication Programmes in India. *Bioethics*, 19(4), 393-406.

[722] Paul, Y. (2005). Polio eradication programme: Some Ethical Issues. *Indian Journal of Medical Ethics*, II(4); Paul, Y, & Dawson, A. (2005). Some Ethical Issues Arising from Polio Eradication Programmes in India. *Bioethics*, 19(4), 393-406.

vaccinated children.[723] This approach used by WHO and UNICEF in implementing the polio eradication program in India ignored ethical concerns in implementing public health programmes. The policy decision of not disclosing information on risks associated with OPV to the community in India was justified to maintain a high level of participation in the program.[724]

The blame for the repeated failure of the program was put on parents for not participating in the program.[725] The targeting and blaming of parents for not vaccinating their children and causing paralysis to their children form the core of communication strategies and IEC materials developed by UNICEF.

Another concern was adequate compensation to children affected by harmful risks of OPV. It is argued that the WHO policy of not informing parents of vaccinated children about the harmful risk of OPV should be compensated with adequate compensation to affected children.[726]

Public health experts in India have demanded compensation and rehabilitation of children for children affected by wild polio, non-polio AFP, and vaccine-induced paralytic polio since 1995.[727] However, the polio eradication program in India made no provisions for

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[723] Paul, Y, & Dawson, A. (2005). Some Ethical Issues Arising from Polio Eradication Programmes in India. *Bioethics*, 19(4), 393-406.
[724] Paul, Y, & Dawson, A. (2005). Some Ethical Issues Arising from Polio Eradication Programmes in India. *Bioethics*, 19(4), 393-406.
[725]Sathyamala, C., Mittal, O., Dasgupta, R., and Priya, R. (2005). Polio Eradication Initiative in India: Deconstructing the GPEI. *International Journal of Health Services*, 35(2), 361-83; Banerji, D., Deohar, N.S., Qadeer, I. Sathyamala, C., Mittal, O., Priya, R., et al. (2008). *Memorandum on Pulse Polio: Submitted to the World Health Organization, UNICEF, and the Government of India, on 7 April 2004, The World Health Day.* (Retrieved from http://aidanindia.worpress.com/2008/08/12/memorudum-on-pulse-polio/)
[726] Paul, Y, & Dawson, A. (2005). Some Ethical Issues Arising from Polio Eradication Programmes in India. *Bioethics*, 19(4), 393-406.
[727] Banerji, D., Deohar, N.S., Qadeer, I. Sathyamala, C., Mittal, O., Priya, R., et al. (2008). *Memorandum on Pulse Polio: Submitted to the World Health Organization, UNICEF, and the Government of India, on 7 April 2004, The World Health Day.* (Retrieved from http://aidanindia.worpress.com/2008/08/12/memorudum-on-pulse-polio/)

developing a system of compensating the victims of harmful risks of OPV. Thus, the top-down model of social mobilization used in the polio eradication program neglected ethical concerns in implementing the program. This resulted in lack of trust among the community in the program and increased social resistance to the program.

6.6 Epidemiological Limitations of OPV in India

The polio eradication program failure in India was attributed to major vaccine-related risk factors. Particularly in northern parts of India polio program is reasoned to suffer from three major problems- vaccine failure (high incidence of paralytic polio cases caused by OPV), high incidence of VAPP cases caused by mutant neuro-virulent vaccine virus cases and non-availability of inactivated polio vaccine (IPV).[728]

6.6.1 Trivalent OPV Failure- Viruses and vaccines' behaviour is sensitive to and strongly influenced by their environment. One of the significant risks associated with trivalent OPV reported in India was the failure to boost immunity in vaccinated children, called vaccine failure. The trivalent oral polio vaccine, which eliminated polio in developed countries, showed poor efficacy in different epidemiological and environmental conditions in endemic countries.[729] It has been known for a long that children in tropical and developing countries respond poorly to OPV. In northern parts of India, response to OPV in boosting immunity against the polio virus was poor, with a high incidence of polio cases of wild poliovirus (WPV), frequent cases of outbreaks of poliovirus, and a high incidence of vaccine associated paralytic

[728] Paul, Y. & Priya (2004). Polio eradication in India: Some Observations. *Vaccine*, 22,4144–4148; Paul, Y. (2005). Polio eradication programme: Some Ethical Issues. *Indian Journal of Medical Ethics*, II(4); Paul, Y, & Dawson, A. (2005). Some Ethical Issues Arising from Polio Eradication Programmes in India. *Bioethics*, 19(4), 393-406.

[729] Grassly, N.C., Fraser, C., Wenger, J., Deshpande, J.M., Sutter, R.W., Heymann, D.L., et al. (2006). New strategies for the elimination of polio from India. *Science*.314, 1150-3.

poliomyelitis (VAPP) cases.[730] The variant nature of OPV in different contextual environments of India raised doubts about the safety and effectiveness of OPV and on eradication goals among the scientific community and public health experts.[731]

Trivalent oral polio vaccine (OPV) efficacy suffered from epidemiological, environmental, and genetic factors in northern parts of Uttar Pradesh and Bihar states.[732] The trivalent oral polio vaccine (tOPV) has been used since the beginning of the polio immunization program in India and constitutes three strains of virus type 1, 2, and 3 of wild poliovirus (WPV). The type 2 wild polio virus was eliminated in October 1999.

By 2000 it was hoped that polio would be eradicated in India. However, a high number of paralytic polio cases and VAPP cases with frequent outbreaks in northern parts of India raised the worldwide debate on the efficacy of OPV. This demanded the need to study the reasons and strategies to tackle the growing problem immediately for India's polio eradication program's success.[733]

It was generally attributed that the failure of the program in India and a large number of paralytic polio cases were because of the large number of missed children in the polio eradication program and routine immunization, especially in high-risk areas.[734] Thus,

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[730] Paul, Y. & Priya (2004). Polio eradication in India: Some Observations. *Vaccine*, 22,4144–4148; Melnick. J.L. (1978). Advantages and disadvantages of killed and live poliomyelitis vaccines, *Bull World Health Organization*, 56(1): 21-38s

[731] Paul, Y. & Priya (2004). Polio eradication in India: Some Observations. *Vaccine*, 22,4144–4148; Paul, Y. (2005). Polio eradication programme: Some Ethical Issues. *Indian Journal of Medical Ethics*, II(4); Paul, Y, & Dawson, A. (2005). Some Ethical Issues Arising from Polio Eradication Programmes in India. *Bioethics*, 19(4), 393-406.

[732] Grassly, N.C., Fraser, C., Wenger, J., Deshpande, J.M., Sutter, R.W., Heymann, D.L., et al. (2006). New strategies for the elimination of polio from India. *Science*.314, 1150-3; Grassly et al. (2007). Protective efficacy of a monovalent oral type 1 poliovirus vaccine: a case-control study. *Lancet*, 369, 1356-62.

[733] Paul, Y. (2007). What needs to be done for polio eradication in India? *Vaccine*, 25, 6431–6436.

[734]Paul, Y, & Dawson, A. (2005). Some Ethical Issues Arising from Polio Eradication Programmes in India. *Bioethics*, 19(4), 393-406; Sathyamala, C., Mittal, O., Dasgupta, R., and Priya, R. (2005). Polio Eradication Initiative in India: Deconstructing the GPEI. *International Journal of Health Services*, 35(2), 361-83; Dasgupta R, Chaturvedi S, Adhish S.V, Ganguly K.K, Rai S, Sushant, L, & Arora, K.N. (2008) Social Determinants and Polio 'Endgame': A Qualitative Study in High-Risk Districts of India. *Indian Pediatrics*, 359(45); Dasgupta, R.

incomplete immunization coverage in regions developed the risk of polio transmission in unvaccinated or partially vaccinated children.

However, one of the significant risks associated with OPV reported in India was the failure to boost immunity in vaccinated children. Contrary to popular belief, the majority of the children who were affected by paralytic poliomyelitis due to poliovirus received more than three doses of OPV.[735]. In India, as per the National Polio Surveillance Project (NPSP), data percentage of children who developed polio between 1998 and 2003, 33 per cent to 60 per cent received four or more doses of OPV. Uttar Pradesh and Bihar reported a high incidence of WPV polio cases despite high immunization coverage (90 per cent) and administering more than four trivalent oral polio vaccine doses to children.[736] This raised questions on the overall effectiveness of OPV in producing immunity in polio vaccine receivers against the polio infection despite full participation in the program[737]

Full immunization of children with OPV could not eliminate the virus in northern parts of India compared to other parts of the country, which raised concerns on the vaccine's efficacy and risk of vaccine failure.

(2009). Serious Messages Behind VDPV Cases in India. *Indian Journal of Pediatrics*, 46; Chaturvedi et al. (2009). Deconstructing Social Resistance to Pulse Polio Campaign in Two North Indian Districts. *Indian Pediatrics,* 974(46); Paul, Y. (2007). What needs to be done for polio eradication in India? *Vaccine*, 25, 6431–6436; United Nations Children's Fund (UNICEF). (2013). *Eradicating polio getting to zero resistance*. UNICEF, Lucknow. (Retrieved from www.unicef.org); Grassly, N.C., Fraser, C., Wenger, J., Deshpande, J.M., Sutter, R.W., Heymann, D.L., et al. (2006). New strategies for the elimination of polio from India. *Science.*314, 1150-3; Grassly et al. (2007). Protective efficacy of a monovalent oral type 1 poliovirus vaccine: a case-control study. *Lancet*, 369, 1356-62.

[735] Paul, Y. (2005). Polio eradication programme: Some Ethical Issues. *Indian Journal of Medical Ethics*, II(4); Paul, Y, & Dawson, A. (2005). Some Ethical Issues Arising from Polio Eradication Programmes in India. *Bioethics*, 19(4), 393-406; Sathyamala, C., Mittal, O., Dasgupta, R., and Priya, R. (2005). Polio Eradication Initiative in India: Deconstructing the GPEI. *International Journal of Health Services*, 35(2), 361-83.

[736]Paul, Y. & Priya (2004). Polio eradication in India: Some Observations. *Vaccine*, 22,4144–4148; Grassly, N.C., Fraser, C., Wenger, J., Deshpande, J.M., Sutter, R.W., Heymann, D.L., et al. (2006). New strategies for the elimination of polio from India. *Science.*314, 1150-3.

[737] Paul, Y. & Priya (2004). Polio eradication in India: Some Observations. *Vaccine*, 22,4144–4148; Paul, Y. (2005). Polio eradication programme: Some Ethical Issues. *Indian Journal of Medical Ethics*, II(4); Paul, Y, & Dawson, A. (2005). Some Ethical Issues Arising from Polio Eradication Programmes in India. *Bioethics*, 19(4), 393-406.

Vaccine failure with OPV can occur due to poor quality of vaccine, some inhibitors in the gut of the vaccine, and poor quality of OPV affected during manufacture, transportation or storage. Studies reported unknown epidemiological risk factors causing vaccine failure in northern regions as the vaccine's efficacy was higher in other parts of India.[738] Factors related to vaccine failure with OPV were related to host immunity and increased exposure to polio infection reported were overcrowding; poor sanitation; malnutrition; high population density; genetic factor in the host, causing variability in response to antibody formation in individuals; high prevalence of diarrhoeal disease and other infections, interfering with the efficacy of trivalent oral polio vaccines and enabling transmission of wild polio in northern parts of UP. Factors related to vaccine failure were poor vaccine potency because of poor manufacturing, transportation or storage; poor medical facilities; and low participation in vaccination campaigns among families and communities.[739]

Like any other infectious disease, polio infection depends on host immunity and environmental risk factors. This is significant in developing countries where nutrition and environment are coincident risk factors in infectious disease. Failure of the OPV vaccine to boost immunity and incomplete immunization coverage in high-risk states developed the risk of polio transmission in unvaccinated or partially vaccinated children.

6.6.2 Risks of OPV- The vaccine problems in India's PPI program were not only attributed to its low potency. However, severe safety issues were involved with the polio vaccine used in

[738] Grassly, N.C., Fraser, C., Wenger, J., Deshpande, J.M., Sutter, R.W., Heymann, D.L., et al. (2006). New strategies for the elimination of polio from India. *Science*.314, 1150-3; Grassly et al. (2007). Protective efficacy of a monovalent oral type 1 poliovirus vaccine: a case-control study. *Lancet*, 369, 1356-62.
[739] Grassly, N.C., Fraser, C., Wenger, J., Deshpande, J.M., Sutter, R.W., Heymann, D.L., et al. (2006). New strategies for the elimination of polio from India. *Science*.314, 1150-3; Grassly et al. (2007). Protective efficacy of a monovalent oral type 1 poliovirus vaccine: a case-control study. *Lancet*, 369, 1356-62.

the country. Along with vaccine failure, vaccine-associated paralytic polio (VAPP)[740] in India was a significant concern raised from time to time by eminent scientists and public health scholars.

Apart from trivalent OPV vaccine failure, there is an associated OPV risk known as Vaccine Associated Paralytic Poliomyelitis (VAPP). Oral polio vaccine is a live attenuated vaccine - poliovirus in OPV during the process of immunity formation in the gut of vaccine recipient may mutate and become neurovirulent, causing VAPP. Thus, OPV in children can cause paralysis because of mutant neurotoxic vaccine polioviruses known as vaccine-derived wild-like poliovirus (VDWL viruses. This vaccine-related iatrogenic harm caused by OPV in children is called vaccine-associated paralytic poliomyelitis (VAPP). Vaccine Viruses also can circulate. Epidemiologically prone to transmission to unvaccinated children called vaccine-derived poliovirus. If it occurs in the vaccine recipient, it is called 'recipient VAPP'. Because of the secondary spread of mutant neurovirulent vaccine polioviruses, VAPP can occur in non-immune close contacts called 'contact VAPP cases.[741]

A high number of VAPP cases were reported in India, causing paralytic polio in children. The use of OPV increased the risk of VAPP cases in the community in India. However, discontinuation or poor immunization coverage of OPV increased the risk of circulating vaccine-derived polioviruses in the country (cVDPV).[742] A high number of VAPP

[740] Oral polio vaccine is live attenuated vaccine; polio virus in OPV during the process of immunity formation in gut of vaccine recipient may mutate and become neurovirulent. Thus, OPV in children can cause paralysis because of mutant neurotoxic vaccine polioviruses known as vaccine derived wild-like poliovirus (VDWL viruses). If it occurs in vaccine recipient it is called 'recipient VAPP'. Because of secondary spread of mutant neurovirulent vaccine polioviruses, VAPP can occur in non-immune close contacts called as 'contact VAPP cases.

[741] Paul, Y. (2006). Vaccine Polioviruses in Stool Samples of AFP Cases. *Indian Journal of Community Medicine*,31(3); Paul, Y. (2005). Polio eradication programme: Some Ethical Issues. *Indian Journal of Medical Ethics*, II(4); Paul, Y, & Dawson, A. (2005). Some Ethical Issues Arising from Polio Eradication Programmes in India. *Bioethics*, 19(4), 393-406.

[742] Dasgupta, R. (2009). Serious Messages Behind VDPV Cases in India. *Indian Journal of Pediatrics*, 46.

cases was reported in India, causing paralytic polio in children. Circulating vaccine-derived polioviruses can acquire the poliovirus properties again and can be re-introduce among populations in any region causing polio outbreaks.[743] Only type 2 of cVDPVs is reported from countries. However, India not only experienced type 2 of cVDPVs emergence as in other countries but also type 1 cVDPV.[744]

The safety or risk factor associated with OPV was that it was becoming the cause of paralytic polio in children receiving it. The debate on IPV use in PPI campaigns to reduce the increased risk of VAPP in children was frequent among scientists and public health scholars.[745] It was estimated that 60-75 per cent of VAPP were reported annually in India, causing paralytic polio in children. [746]

It was iatrogenic harm caused by OPV in children. By 2004 -2005 the safety of the oral polio vaccine was widely discussed in various scientific studies and papers, along with the problem of OPV failure. Serious ethical concerns were raised regarding the safety and efficacy of OPV-based mass immunization campaigns in India. It was argued that in the country safety of polio vaccination was grossly neglected with the use of oral polio vaccine and the non-availability of inactivated polio vaccine (IPV).[747]

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[743] John, T.J. (2004). A developing country perspective on vaccine-associated paralytic poliomyelitis. *Bulletin of the World Health Organization*, 82(1), 53-57.
[744] Dasgupta, R. (2009). Serious Messages Behind VDPV Cases in India. *Indian Journal of Pediatrics*, 46.
[745] John, T.J. (2016). India's Research Contributions Towards Polio Eradication (1965-2015). *Indian Journal of Pediatrics*,53, (1-6).
[746] In immunocompromised children mutant vaccine and wild polio virus replicate for many months or years and thus spread infection for prolonged period in community. (Paul, Y. (2005). Polio eradication programme: Some Ethical Issues. *Indian Journal of Medical Ethics*, II(4))
[747] Paul, Y. & Priya (2004). Polio eradication in India: Some Observations. *Vaccine*, 22,4144–4148; Paul, Y. (2006). Vaccine Polioviruses in Stool Samples of AFP Cases. *Indian Journal of Community Medicine*,31(3); Paul, Y. (2005). Polio eradication programme: Some Ethical Issues. *Indian Journal of Medical Ethics*, II(4); Paul, Y, & Dawson, A. (2005). Some Ethical Issues Arising from Polio Eradication Programmes in India. *Bioethics*, 19(4), 393-406.

It was also considerably researched and reported that immunity-compromised children[748] were at a higher risk of developing VAPP in India.[749]

In immunocompromised children, mutant vaccines and wild poliovirus replicate for many months or years and thus spread the infection for a prolonged period in the community.[750] The universal estimated risk of VAPP reported among immunodeficient infants is 3,200 to 6,800-fold higher than immunocompetent infants. It was estimated that immunocompromised children are at 2000 times higher risk of VAPP compared to immunocompetent children in India.[751]

The risk associated with OPV use of VAPP among immune-compromised children was overlooked in India in promoting and administering OPV.[752]

The AFP cases are indicative of VAPP cases. The rise in AFP cases, especially in northern parts of India, pointed toward a rise in vaccine-derived poliovirus cases in India.[753] However, National Polio Surveillance Project (NPSP) did not detected the AFP cases and discarded them as non-polio cases.[754]

Thus, the OPV vaccine carries a greater risk of causing harm to affected individuals. The risk associated with OPV use of VAPP among immune-compromised children was

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[749] Paul, Y. (2005). Polio eradication programme: Some Ethical Issues. *Indian Journal of Medical Ethics*, II(4).
[750] Paul, Y. (2005). Polio eradication programme: Some Ethical Issues. *Indian Journal of Medical Ethics*, II(4).
[751] Paul, Y. & Priya (2004). Polio eradication in India: Some Observations. *Vaccine*, 22,4144–4148.
[752] Banerji, D., Deohar, N.S., Qadeer, I. Sathyamala, C., Mittal, O., Priya, R., et al. (2008). *Memorandum on Pulse Polio: Submitted to the World Health Organization, UNICEF, and the Government of India, on 7 April 2004, The World Health Day.* (Retrieved from http://aidanindia.worpress.com/2008/08/12/memorudum-on-pulse-polio/)
[753] Neogi, B.S. (2006).Polio Declining but AFP on the Rise. *Indian Journal of Pediatrics*, 186, 43.
[754] Paul, Y. (2006). Vaccine Polioviruses in Stool Samples of AFP Cases. *Indian Journal of Community Medicine*,31(3).

overlooked in India in promoting PPI and administering OPV to children.[755] Serious ethical concerns were raised about the safety and efficacy of the OPV-based mass immunization campaign. The need to evaluate the poor efficacy of OPV, high rate of vaccine failure and high incidence of VAPP cases were made to reduce the harm caused to children. However, OPV-related risks were not accounted for and reviewed in the polio eradication program in India.[756] The WHO personnel and the Indian government never publicly discussed OPV's risk, causing paralysis. The WHO estimates OPV risk of causing paralysis was attributed to roughly one child being paralyzed per million doses of vaccine distributed. However, this rate of OPV risk was considered more significant for highly populated countries such as India with repeated PPI rounds and children under-five years of age given more than 3 three doses of OPV.[757]

6.6.3 Non-Availability of IPV in India - Because of the failure of the trivalent OPV vaccine and the risk of vaccine-associated paralytic poliomyelitis (VAPP) in India, there was a constant debate and demand on introducing IPV for polio eradication in India. There was a strong group of public health professionals supporting IPV use along with OPV.

Studies estimated that the non-availability of IPV, especially for immune-compromised children, was also one of the causes of the high incidence of polio cases in the country. Introducing IPV in the PPI program was highly recommended to reduce the risk of VAPP, especially among immunity-compromised children in high-risk areas, to provide protection

[755] Banerji, D., Deohar, N.S., Qadeer, I. Sathyamala, C., Mittal, O., Priya, R., et al. (2008). *Memorandum on Pulse Polio: Submitted to the World Health Organization, UNICEF, and the Government of India, on 7 April 2004, The World Health Day.* (Retrieved from http://aidanindia.worpress.com/2008/08/12/memorudum-on-pulse-polio/)

[756] Paul, Y. (2005). Polio eradication programme: Some Ethical Issues. *Indian Journal of Medical Ethics*, II(4); Paul, Y, & Dawson, A. (2005). Some Ethical Issues Arising from Polio Eradication Programmes in India. *Bioethics*, 19(4), 393-406.

[757] Sathyamala, C., Mittal, O., Dasgupta, R., and Priya, R. (2005). Polio Eradication Initiative in India: Deconstructing the GPEI. *International Journal of Health Services*, 35(2), 361-83.

against poliovirus in children and the community.[758] It was considered a necessary policy step to protect children and communities from the risk of developing paralytic polio.[759]

Overlooking the above ethical severe concerns on the risk associated with OPV, the vaccine policy changed in India to reduce the high incidence of polio cases in high-risk areas. India changed the vaccine from trivalent OPV to monovalent oral type 1 and 3 poliovirus vaccine in 2005. The monovalent oral polio vaccine was considered three times more effective in conditions of the high prevalence of diarrhoea and other infections than trivalent OPV.[760]

Despite introducing monovalent polio vaccine type 1 (mOPV1) and type 3 (mOPV3) in UP, there was no decline in polio cases in UP and Bihar.[761] Thus it was suggested to introduce a new polio vaccine to tackle the problem of vaccine failure and cVDPV cases.[762] Introducing a monovalent vaccine for children in high-risk areas ignoring the high incidence of AFP cases and OPV-related risk factors raised questions on the consideration of public health ethics in the implementation of the polio eradication program in the country.

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[758] Paul, Y. (2005). Polio eradication programme: Some Ethical Issues. *Indian Journal of Medical Ethics*, II(4); Paul, Y. & Priya (2004). Polio eradication in India: Some Observations. *Vaccine*, 22,4144–4148; Paul, Y. (2007).Role of genetic factors in polio eradication: New challenge for policymakers. *Vaccine* 25,8365–8371; Paul, Y. (2007). What needs to be done for polio eradication in India? *Vaccine*, 25, 6431–6436; John, T.J. (2005). Will India need inactivated poliovirus vaccine (IPV) to complete polio eradication? *Indian Journal Medical Research*, 122, 365-367.

[759] Paul, Y. (2005). Polio eradication programme: Some Ethical Issues. *Indian Journal of Medical Ethics*, II(4); Paul, Y. & Priya (2004). Polio eradication in India: Some Observations. *Vaccine*, 22,4144–4148; Paul, Y. (2007).Role of genetic factors in polio eradication: New challenge for policymakers. *Vaccine* 25,8365–8371; Paul, Y. (2007). What needs to be done for polio eradication in India? *Vaccine*, 25, 6431–6436; John, T.J. (2006). Polio Eradication: A National Commission Required. *Economic and Political Weekly*, 23,5229- 5234.

[760] Grassly, N.C., Fraser, C., Wenger, J., Deshpande, J.M., Sutter, R.W., Heymann, D.L., et al. (2006). New strategies for the elimination of polio from India. *Science*.314, 1150-3; Grassly et al. (2007). Protective efficacy of a monovalent oral type 1 poliovirus vaccine: a case-control study. *Lancet*, 369, 1356-62.

[761] Paul, Y. (2007).Role of genetic factors in polio eradication: New challenge for policymakers. *Vaccine* 25,8365–8371.

[762] Paul, Y. (2007).Role of genetic factors in polio eradication: New challenge for policymakers. *Vaccine* 25,8365–8371; Paul, Y. & Priya (2004). Polio eradication in India: Some Observations. *Vaccine*, 22,4144–4148; Dowdle, R. W., Gourville, D.E., Kew, M.O., Pallansch, A.M., & Wood, J D. (2003). Polio eradication: the OPV paradox. *Reviews in Medical Virology*, 13, 277–291.

To eliminate the risk of vaccine-associated paralytic polio (VAPP) and circulating vaccine-derived poliovirus (cVDPV), WHO planned the removal of trivalent OPV vaccines after eradication. The Polio Eradication and Endgame Strategic Plan 2013-2018 planned the phased removal of all OPVs from countries called the *The Switch* (along with polio end game plan). The Switch program planned to switch trivalent OPV (tOPV) to bivalent OPV (bOPV) and introduce inactivated polio vaccine (IPV) into routine immunization programs in all countries by the end of 2015. The switch was planned to take place in all countries during the season of low poliovirus transmission in many countries and took place between April 17th and May 1st 2016. The global synchronization of the switch was done to eliminate the risk of importing a vaccine-derived poliovirus (cVDPV) type 2 from other countries still using trivalent OPV (tOPV). The scientific rationale for the switch program was that the trivalent oral polio vaccine (tOPV) contains all three poliovirus serotypes (1, 2, and 3), and the use of this vaccine has led to the eradication of type 2 WPV in 1999. However, according to the global polio eradication initiative (GPEI), 90 per cent of cVDPV (750) cases and approximately 40 per cent of VAPP cases occurred between 2000-2012 because of the type 2 serotype of tOPV. It also interferes with the immunity response to poliovirus type 1 and 3 serotypes. Thus, to eliminate the risk of type 2 cVDPV, switch from tOPV to bOPV, which contains only types 1 and 3. The bOPV does not protect against the type 1 and 3 cVDPVs but only removes type 2 cVDPV.[763]

[763] WHO (2015). *Preparing for the withdrawal of all oral polio vaccines (OPVs): Replacing trivalent OPV (tOPV) with bivalent OPV (bOPV)- Briefing note*. (Retrieved from www.polioeradication.org); World Health Organization. (2013). *Polio Eradication &Endgame Strategic Plan 2013-2018*. WHO, France. (Retrieved from www.polioeradication.org)

The polio end-game strategy suggested that bOPV will protect against transmission of WPV1 and WPV3, and once all wild polioviruses are eradicated, all OPVs will be withdrawn from countries. The deadline fixed for the removal of all OPVs from countries was 2020.[764]

Intramuscular injections were reported as a significant risk factor in northern areas, increasing the risk of paralysis in children.[765] In the United States, similar concerns on the risk of intramuscular injections and polio provocation were debated among health professionals. However, such harmful risk was accounted for against the risk of polio provocation by introducing reforms in immunization practices.[766] In India, policy discussions on the risk of intramuscular injections did not take any form of debate, and no effort was taken in the polio eradication program to reduce this risk and save lives.

6.7 Paralytic Poliomyelitis & Role of Environmental Risk Factors

Like any other infectious disease, polio infection depends on host immunity and environmental risk factors. This is significant in developing countries where nutrition and environment are coincident risk factors in infectious disease. However, the GPEI model implemented in developing countries with OPV as a single strategy ignored the essential social epidemiological risk factors causing polio. In India, along with vaccine failure, the population's nutritional status and environmental sanitation were major contextual risk factors for the transmission of polio infection. A high incidence of AFP polio cases was reported from pockets

[764] WHO (2015). *Preparing for the withdrawal of all oral polio vaccines (OPVs): Replacing trivalent OPV (tOPV) with bivalent OPV (bOPV)- Briefing note*. (Retrieved from www.polioeradication.org); World Health Organization. (2013). *Polio Eradication &Endgame Strategic Plan 2013-2018*. WHO, France. (Retrieved from www.polioeradication.org)

[765] Varghese, M., Qadeer, I., and Mohan, D. (1997). Paralytic poliomyelitis in a rural area in North India. *National Medical Journal of India*, 10(1), 8–10; Kohler, K. A., et al. (2003).Outbreak of poliomyelitis due to type 3 poliovirus, Northern India, 1999–2000: Injections a major contributing factor. *International Journal of Epidemiology*, 32(2), 272-277.

[766] Mawdsley, E.S. (2013). Balancing Risks: Childhood Inoculations and America's Response to the Provocation of Paralytic Polio. *Social History of Medicine*, 26 (4), 759–778.

of high-risk areas of northern India of UP and Bihar even after administering more than three doses of OPV.

The challenges in implementing the polio program in India were not just ensuring adequate polio immunity among children. But the critical risk factors of polio infection and vaccine failure in India were immune deficiency and poor sanitation, which were largely ignored in program planning and implementation.[767]

The delays caused in recognizing social determinants of health (SDH) as an essential factor for program planning since the beginning added to increased frequency of SIAs rounds each year to improve program performance but failed in efforts to stop the poliovirus completely.

"Every year rounds of OPV were conducted as social determinants were not seen as important factor initially. Later on, SDH such as water and sanitation, functional literacy, female literacy, waste management to were focused. The success of WASH campaign helped in the getting polio eliminated. The OPV required the action of or combination of SDH activities to eliminated virus." [768]

Risk factors affecting the immunity of the host and increased environmental exposure were major factors decreasing the resistance to poliovirus among the population, along with causes of vaccine failure in high-risk areas. The studies reported unknown epidemiological risk factors causing vaccine failure in northern regions of the country as the efficacy of vaccines was higher in other parts of India.[769]

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[767] Sathyamala, C., Mittal, O., Dasgupta, R., and Priya, R. (2005). Polio Eradication Initiative in India: Deconstructing the GPEI. *International Journal of Health Services*, 35(2), 361-83; Kalra, A. (2008). Polio Eradication and Environment. *Indian Pediatrics*, 45, 388-389.

[768] Interview

[769] Grassly, N.C., Fraser, C., Wenger, J., Deshpande, J.M., Sutter, R.W., Heymann, D.L., et al. (2006). New strategies for the elimination of polio from India. *Science*.314, 1150-3; Grassly et al. (2007). Protective efficacy of a monovalent oral type 1 poliovirus vaccine: a case-control study. *Lancet*, 369, 1356-62.

Overcrowding; poor sanitation; malnutrition; high population density; genetic factor in the host, causing variability in response to antibody formation in individuals; high prevalence of diarrhoeal disease and other infections were interfering with the efficacy of trivalent oral polio vaccines and enabling transmission of polio in northern parts of UP.[770]

The reported vaccine failure, along with many vaccine-related rumours and social resistance to OPV in UP, was reported from socially marginalized populations deprived of basic amenities, health infrastructure and services. Thus, the population in UP was deprived of immunity and was at increased environmental risk of exposure to polio infection.[771] These risk factors were largely ignored in the conceptualization and implementation of the polio eradication program.

Among the polio policy experts, scientists, public health professionals, and activities, it is still debatable whether polio elimination in India resulted from focus on addressing SDH along with OPV and program strategies or from exclusive focus on SDH given to the final phases of the program implementation. The success of the polio eradication program can be attributed to vaccines, but SDH was also a significant factor.

[770] Grassly, N.C., Fraser, C., Wenger, J., Deshpande, J.M., Sutter, R.W., Heymann, D.L., et al. (2006). New strategies for the elimination of polio from India. *Science*.314, 1150-3; Grassly et al. (2007). Protective efficacy of a monovalent oral type 1 poliovirus vaccine: a case-control study. *Lancet*, 369, 1356-62; Paul, Y. (2007).Role of genetic factors in polio eradication: New challenge for policymakers. *Vaccine* 25,8365–8371; Paul, Y. & Priya (2004). Polio eradication in India: Some Observations. *Vaccine*, 22,4144–4148.

[771] Chaturvedi et al. (2009). Deconstructing Social Resistance to Pulse Polio Campaign in Two North Indian Districts. *Indian Pediatrics,* 974(46); Dasgupta R, Chaturvedi S, Adhish S.V, Ganguly K.K, Rai S, Sushant, L, & Arora, K.N. (2008) Social Determinants and Polio 'Endgame': A Qualitative Study in High-Risk Districts of India. *Indian Pediatrics*, 359(45); United Nations Children's Fund (UNICEF). (2013). *Eradicating polio getting to zero resistance*. UNICEF, Lucknow. (Retrieved from www.unicef.org); Ansari, A.M., Khan, Z. & Khan, M. I. (2007). Reducing resistance against polio drops. *The Journal of the Royal Society for the Promotion of Health*, 127(6), 276-279; Ansari et al.(2013). Role of social mobilization in tackling the resistance to polio eradication program in underserved communities of Aligarh, India. *South-East Asia Journal of Public Health*, 3(2), 23-29.

One crucial policy learning from India's polio elimination success story is that it was recognized much later during the last phases of program implementation that social determinants of health are essential factors impacting the progress of PPI campaigns in endemic regions. This resulted in wasting funds and other resources used for conducting repetitive PPI campaigns in India to stop the poliovirus.

"One lesson learned by global community was the SDH is important as billions of dollars were spent on the program because of the repeated program in India ignoring the determinants of the context where the program was implemented. It was frustrating for the global community."[772]

"WASH activities, the sense of social obligation within the community, etc., were required for the program to work. Door-to-door literacy was required in the campaign to inform the community better, female literacy levels were required, hygiene practices were initiated, and water and sanitation were required to improve gut immunity.[773]

The top-down approach used to implement the program did not work. Later, the program adopted several contextual level strategies to reduce risks of socio-cultural, epidemiological, and economic risks and improve the oral polio vaccine effectiveness. Efforts were put to improve water, sanitation and hygiene, improve acceptance of programs among the community and increase social obligation towards PPI, and focus on increasing population knowledge and decreasing information gaps. Focusing on implementing strategies to improve sanitation and reduce the faecal-oral route of poliovirus transmission among children, particularly in early infancy and young children, became essential to improve gut immunity.

India's polio policy changed several times per the region's epidemiological and environmental needs to eliminate the polio virus. However, the changes were explicitly focused on changes in vaccines from trivalent to monovalent vaccines and on changing parents' attitudes towards OPV through implementing social mobilization strategies in high-risk areas.

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[772] Interview
[773] Interview

Thus, in implementing the polio eradication program, host immunity-related risk factors, environmental, and OPV-related risk factors causing paralytic polio cases, were largely ignored in India.

6.7 Why Achieving Polio Elimination is Still Debatable - *Post-Polio Eradication Challenges*

It was clear from studies and debates around reported VAPP cases that OPV was a cause of paralytic polio instead of preventing it in India. A high incidence of VAPP cases was reported in children who received polio vaccination. Thus, the outbreaks and rises in AFP cases, especially in northern parts of India, pointed to a rise in vaccine-derived poliovirus cases in India.[774] The risk was multi-fold in endemic regions of UP and Bihar states, where PPI campaigns were increased to 10 per year to compensate for the low routine immunization coverage in very young children and eliminate the type 1 poliovirus with the use of mOPV.

Among the public health experts and activists, it is generally believed that OPV use in India became a cause of paralytic polio instead of preventing it. The failure of the polio eradication program in reducing high polio incidence and a high number of VAPP cases questioned the overall safety and effectiveness of OPV in the country. The OPV-associated risk factors were ignored in India in the planning and implementation of the program. This started a debate among public health experts on the harmful effects of OPV in children and the neglect of public health ethics in implementing the polio program.

The questions on the safety of the OPV were undermined by the GOI and the partner agencies and international polio experts with its continued use in the PPI cycle and the

[774] Neogi, B.S. (2006).Polio Declining but AFP on the Rise. *Indian Journal of Pediatrics*, 186, 43.

introduction of OPV. However, repeated vaccination of children with more than recommended polio doses in high-risk Indian districts was considered a risk to children.

"Repeat vaccine to same children's kids sometimes 45 times it involves risks also."[775]

The risk associated with the use of OPV causing VAPP among immune-compromised children was overlooked by GOI.[776] Risk factors were not accounted for and reviewed in the polio eradication program in India.[777]

Globally also rise in VAPP cases in India was not considered an acute problem in India, and the focus continued to be on the use of OPV.

"I do not have any knowledge about whether in India the VAPP cases were any higher or lower or no, as equal number of cases were reported in other countries as well. So, policy recommendation of using of OPV was necessary."[778]

It was only in 2006 that GOI licensed the use of IPV in India. In late 2006, IEAG requested GOI for the first time to undertake a pilot study of the supplemental dose of IPV along with mOPV1 birth dose in a few blocks of western UP.

However, despite repeated appeals by public health scholars and scientists, IPV was never introduced in PPI campaigns. Its uses were limited to private health providers only. There

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[775] Interview

[776] Banerji, D., Deohar, N.S., Qadeer, I. Sathyamala, C., Mittal, O., Priya, R., et al. (2008). *Memorandum on Pulse Polio: Submitted to the World Health Organization, UNICEF, and the Government of India, on 7 April 2004, The World Health Day.* (Retrieved from http://aidanindia.worpress.com/2008/08/12/memorudum-on-pulse-polio/)

[777] Paul, Y. (2005). Polio eradication programme: Some Ethical Issues. *Indian Journal of Medical Ethics*, II(4); Paul, Y, & Dawson, A. (2005). Some Ethical Issues Arising from Polio Eradication Programmes in India. *Bioethics*, 19(4), 393-406.

[778] Interview

was considerable apprehension within the GOI and among public health scholars about using IPV in the PPI program because of an expensive vaccine compared to OPV.[779]

Large-scale use of OPV in PPI campaigns would not have increased the overall vaccine procurement cost of the program but also demanded change in the vaccine delivery. Administering drops of OPV in PPI was feasible by anyone compared to IPV, which needs trained professionals to intra-muscular the polio vaccine to eligible children.[780] Thus, OPV-associated risks were overlooked in India in the planning and implementation of the PPI campaigns, and IPV was never introduced in the program.

However, the risk of vaccine-derived polioviruses (VDPVs) increased over the years. Towards the end of the program, isolated cases of VDPVs were reported, but no evidence was found of circulating vaccine-derived poliovirus (cVDPVs).[781] The (cVDPVs) remained a risk for the overall success of the India program in the post-polio eradication phase. Another significant risk associated with the re-emergence of polio in India is the neglect of social determinants of health.

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[779]Interviews; Sathyamala, C., Mittal, O., Dasgupta, R., and Priya, R. (2005). Polio Eradication Initiative in India: Deconstructing the GPEI. *International Journal of Health Services*, 35(2), 361-83; Banerji, D., Deohar, N.S., Qadeer, I. Sathyamala, C., Mittal, O., Priya, R., et al. (2008). *Memorandum on Pulse Polio: Submitted to the World Health Organization, UNICEF, and the Government of India, on 7 April 2004, The World Health Day.* (Retrieved from http://aidanindia.worpress.com/2008/08/12/memorudum-on-pulse-polio/)

[780] Interview

[781] National Surveillance Project A Government of India -WHO initiative. (2009). Current Situation. *AFP Alter*,13(1). (Retrieved from www.npspindia.org); Indian Expert Advisory Group (IEAG). (2009). *Twentieth Meeting of the India Expert Advisory Group for Polio Eradication*, Delhi, India 24-25 June. (Retrieved from http://www.npspindia.org); Indian Expert Advisory Group (IEAG). (2010). *Twenty-Second Meeting of the India Expert Advisory Group for Polio Eradication*, Delhi, India 1-2 November. (Retrieved from www.polioeradication.org); Indian Expert Advisory Group (IEAG). (2011). *Twenty-Third Meeting of the India Expert Advisory Group for Polio Eradication, Delhi*, India 13-14 July. (Retrieved from www.polioeradication.org); Indian Expert Advisory Group (IEAG). (2012). *Twenty Fourth Meeting of the India Expert Advisory Group for Polio Eradication*, Delhi, India 15-16 March. (Retrieved from www.polioeradication.org); Indian Expert Advisory Group (IEAG). (2013). *Twenty-Fifth Meeting of the India Expert Advisory Group for Polio Eradication*, Delhi, India 3 May. (Retrieved from www.polioeradication.org)

"I fear that the polio virus can remerge because of poor social determinants of health, sanitation, and hygiene conditions."[782]

Other challenges for the program remained to maintain high population immunity, mainly through routine immunization, sustaining the high quality of surveillance and laboratories for detection of importation of polio cases and rapid response to address any reported polio case.

[782] Interview

7. SUMMARY AND DISCUSSION

1. Historical Evolution - *From Recognizing Polio as a Disease to its Vaccine Development*

The historical journey of poliomyelitis has two parts: the disease took many decades to be recognized as a disease with its crippling nature. Second, when its virulent nature was dreaded, efforts were made to find its treatment and cure as polio vaccines.

The historical image of poliomyelitis had an image of "crippling symptoms" with withered limbs. The only distinct feature of the disease was the sudden occurrence of temporary paralysis in a healthy child after fever and later becoming permanent in a few cases. For a long period in the history, central understanding prevailed that paralysis in children after the fever is caused by some evil dispel and is inexplicable. It is reasonable to think that the crippling nature followed by fever must have gotten enormous attention. However, this crippling nature was insufficient to establish poliomyelitis as a disease entity for a prolonged period.

It may be assumed that in history that crippling symptom was rare or did not exist at all. However, archaeological and historical evidence signals its sporadic nature in the ancient period, both in adults and infants. The beginning of a scientific understanding of the crippling symptoms started with Hippocrates, who observed clubfoot deformities in children at an early age during his travel throughout Greece and Asia. It was opposed to the dominant view on supernatural or magical reasoning on the crippling symptoms caused in children.

However, poliomyelitis remained clinically inapparent, and the knowledge about understanding the crippling symptoms caused by fever preceded very slowly. The crippling poliomyelitis, for many decades, failed to catch the attention of physicians as a disease requiring clinical studies to understand its nature and treatment.

In the sixteen, seventeen and eighteenth centuries, sporadic crippling cases occurred in children in Europe and America. There were many reasons for not recognizing polio as a disease. Fevers in children were generally considered a common fever with characteristics that have no primary cause and are not accompanied by visible symptoms on skin or body parts swelling. Some fevers that occurred after teething and foul bowls causing lameness (paralysis) in a few children were widely considered acceptable and inevitable. Establishing a relationship between fevers and lameness was also difficult due to delays in reporting lameness in children by parents to doctors making accurate diagnosis difficult.

Further, the medical environment of the seventeenth and most of the eighteenth century in Europe and England did not gave importance to precision in diagnosing diseases and giving names except for some diseases of epidemic nature. Diagnosis of minor illnesses for practicing physicians was considered trivial. More emphasis was given to treating diseases as part of practice for the patients. The strong resistance to the accurate disease diagnosis by the orthodox medical climate maintained that the sporadic nature of fevers to cause paralysis in children remained unnoticed for the prolonged period.

In the late eighteenth and early nineteenth century, substantial research work which followed directed the progress in understanding lameness's nature and its precise medical diagnosis. In the orthodox medical convention of the period, a few scientists' efforts gave the crippling disease a distinct clinical identity. Using the observation methods, they studied paralysis attacks in infants after fever and provided an accurate diagnosis. This progress made crippling disease get its first clinical description, written in medical text named "Diseases of Children" in 1789 by British Physicians. The disease was named "debility of the lower extremities" in the book. Although clinically identified, it took many years for the disease to get clinically recognized.

It was not until the nineteenth century that detailed clinical descriptions of poliomyelitis gave a complete clinical picture from the onset of symptoms to later residual paralysis. Two significant breakthroughs made in the early nineteenth century were recognizing the flaccid nature of paralysis and understanding it was the anterior spinal cord in humans where disease attack caused paralysis by impacting the motor nerves. Ground-breaking work was done by German orthopaedist Jakob Von Heine in 1840. Providing a complete clinical picture of disease progression from early stages to paralysis of limbs followed by long-term care and improvement seen in recovering patients. In 1860 one of the significant findings of Heine's work was that clinical symptoms afflict the central nervous system, particularly the spinal cord. Heine named it spinal infantile and established that the disease causes a particular type of paralysis. However, despite the complete clinical picture based on Heine's work, the scientific studies moved slowly. Much evidence on the pathology and epidemiology of the disease remained unknown until mid of the nineteenth century. The contagion and infectious nature of disease remained unexplored and not understood, especially in an environment where these concepts were in the nascent stages of development. Cases of paralysis in infants clustering at a particular place and time were broadly not recognized and remained unnoticed.

It was not until mid of the nineteenth century that small outbreaks of polio cases were reported by physicians. The clustering of cases of paralysis in infants was first reported in 1836. Three small outbreaks in the mid-nineteenth century in England, St Helena (an isolated island) and Louisiana (United States) were studied by a few physicians who had an aptitude to recognize them. However, these outbreaks of paralysis were scattered outbreaks in communities in which physicians observing them noticed as they could be threatening. Apart from this reporting of polio outbreaks, other outbreaks remained largely unrecognized for a

long period. Thus, before the nineteenth century, the epidemic nature of the disease was something considered uncommon and unknown.

Frequent epidemics of poliomyelitis in the twentieth century made the poliomyelitis a disease with clinical identifiable characteristics and established it as an urgent public health problem in European and American countries. It was from 1868, that outbreaks of poliomyelitis were noticed seriously as the frequency of disease outbreaks increased. These outbreaks were reported from Norway, later reported in other parts of Europe and North America, and spread to other western countries. These epidemics have occurred irreversibly since 1900 with increasing frequency in most temperate regions of western countries. Unusually infant disease in the endemic period poliomyelitis started occurring in the higher age group of 10-15 above and even in adults. An increase in the incidence of age and frequency of epidemic of disease-causing paralysis became a cause of concern and established poliomyelitis epidemiological and public health importance. Thus, it was epidemic and not the endemic nature of the disease that established polio as a disease of the twentieth century. However, sporadic cases of polio occurred in infants before this period.

The epidemic nature of the disease attracted enormous attention and gave poliomyelitis recognition as a significant public health problem. One factor contributing to the increased popularity of poliomyelitis as a disease was the fear associated with polio paralysis among people. Epidemics of polio transformed the disease pattern from sporadic cases to an increase in the frequency of cases. Consequently, it also increased the risk of minor illness occurring with symptoms of fever transforming to primary disease resulting in short-term or long-term/ permanent symptoms of paralysis in fewer cases.

Frequent polio epidemics increased the probability of children getting infected with polio infection, succumbing to temporary or permanent paralysis. This epidemiological nature of the disease-causing young children's lifelong disability was a dreadful experience.

In the early American society of the 1950s, everyone from diseased to non-diseased was affected by the polio outbreak. Frequent epidemics immensely disturbed the public as well as the social life of people. During the epidemics, public places were closed, and adults and children were compelled to live in constant fear of catching the polio infection.

Although there were other diseases with high mortality in this era, polio was a terrifying disease with unknown causes and no effective cure. The frequent epidemics were disastrous for the polio-infected families and impacted the general public daily life. Fear of the disease not only caused immense worry and anxiety. It was considered a novel and dreadful disease of the twentieth century because of its paralytic nature. Permanent and life-long leg deformities in previously healthy children caused by paralytic poliomyelitis added to the fear and anxiety of the public. The lifelong deformities created in a healthy child by this disease created an appalling image, imprinted on the minds of people who witnessed the polio epidemic era.

As epidemics increased, fear among the general public became immense. The growing fear among the public and social pressure demanded urgent attention of governments of western countries for policy actions. Limited scientific understanding of the nature of the disease and its epidemics lacked answers on what causes the disease and any treatment and cure. The government's inability to manage the poliomyelitis epidemics and scientific uncertainty on the causes and cure of this dreadful disease added to the fear of the public.

One of the contributing positive aspects of the frequent polio epidemics was that it pushed the needed scientific understanding immensely, lacking in the endemic period.

Epidemics shifted the scientific approach to understanding poliomyelitis. Thus, frequent epidemics, growing fear among the general public, and the lack of scientific knowledge on disease epidemiology and its cure contributed to its growing scientific recognition by the mid-twentieth century. Poliomyelitis as a disease that got scientific recognition as a significant public health problem. However, it also attracted massive research funding for studies on polio not done before for any other disease.

Although epidemics boosted scientific progress, it took much longer to understand the disease epidemiology and conquer it through vaccination fully. Conquering polio remained a distant dream and was full of uncertainty. Because there was a lack of understanding of virus types, mode of spread and its effective treatment, cure and prevention. Before the 1950s, some of the major scientific discoveries were made in understanding the epidemiology of poliomyelitis. Many important scientific discoveries made on understanding the epidemiology of the disease, its accurate diagnosis and treatment before 1950s came from scientists of Europe and United States and was part of ongoing scientific advancement in tools and technology.

After the development of techniques and rules to discover viruses laid down by Robert Koch's at the beginning of the germ era. Scientific focus shifted to identify viruses resulting in a range of discovery of viruses been discovered. Major breakthrough in discovering acute poliomyelitis virus came through Landsteiner work in 1908 in Vienna. Landsteiner success not only establish the fact that poliomyelitis virus is infectious with characteristics sufficient to cause epidemics. It also opened the gates for multitude of scientific endeavours which were considered beyond reach before the discovery of polio etiological agent.

Major institutions such as Rockefeller Institute for Medical Research in New York became interested in the laboratory work on poliovirus. Simon Flexner then the director of

Rockefeller Institute started building more on the Landsteiner discovery and began experimental laboratory work on poliovirus with his colleagues. It was also an era in which experimental work on polio was highly recognized in laboratories of Unites States. By 1910 Simon Flexner pioneering discoveries was formation of antibodies in humans against polio infection. Understanding the formation of antibodies against poliovirus was considered a major breakthrough in scientific advancement in the field of polio research.

Despite these two pioneer scientific discoveries the scientific advancement in the field of polio research progressed very slowly. Although scientific laboratory work on polio was greatly enhanced after the discovery of poliovirus and formation of antibodies in humans. The general belief and hope among the scientific community were that it will not take much time for polio disease to became a preventable disease. Landsteiner and Flexner works set the foundation for future research work on understanding polio epidemiology and its vaccine development. However, there were many factors which overall slowed the scientific progress to find cure and delayed the polio vaccine development for many years.

By 1913 scientific research work was seriously lacking in understanding the epidemiology of poliovirus. Much of the confusion was on modes of its spread and pathways to human central nervous system. Lab based polio research still needed major innovation for development of polio vaccine. World War I in 1914 impacted the lab-based research work on polio across the countries and specifically in Europe. Many of the major scientists stopped polio research work due to war, lack of sufficient support and funding, and lack of scientific tools for research.

In understanding polio epidemiology, it was largely a mystery of its mode of spread. There were various myths and theories formulated on modes of poliovirus spread and its was

largely debated for a very long time. It was widely believed during this period that poliovirus like other diseases spread from mosquitoes, fly and filthy environment. These myths surrounding the mode of spread of poliovirus corresponded to overall general understanding established at the beginning of twentieth century that insects have major role in the spread of diseases including poliomyelitis. Subsequently the public health measures during this period were largely focused on the use of insecticides and cleanliness drives to prevent poliovirus spread. However, such measures were ineffective and public health authorities failed majorly in controlling the spread of epidemics.

It took many years to understand the accurate mode of polio transmission, later is was became scientifically clear that not insects but human-to human contact with infected person largely through mouth transmit the disease. However, the myths surrounding the modes of poliovirus spread survives for very long even after scientific understanding was evident on human transmission.

By 1917 it was firmly established for a very long period that in humans it is the nasal portal entry from which poliovirus enters central nervous system. However, this scientific understanding was largely controversial for a very long period and was later found to be universally falsely accepted. In 1942 interest in understanding the pathways of poliovirus in humans was again developed. Major breakthrough in scientific understanding was established in 1951 by DM Horstmann of Yale Poliomyelitis Study Unit at Yale University. Horstmann's works firmly established that it was not the nasal pathways. But bloodstream from where the poliovirus makes it way to central nervous system of humans.

By twentieth century major innovation in developing scientific tools for tissue culturing of viruses in laboratory settings was a milestone in scientific revolution and opened doors for

wider possibilities. After many failed attempts to culture poliovirus outside human body in laboratory since 1913. It was only in 1948 onwards when John Enders and his colleagues were finally successful in cultivating three poliovirus serotypes in artificial environment.

In the history of polio research all the discoveries prior to 1950s were milestone which set the pathways for future more advancement research on preventing poliovirus. Much of the confusion on the poliovirus modes of spread, its pathways of poliovirus entry into human body causing infection and paralysis were scientifically investigated and established. For the first time in the history of polio scientific research work it was understood that poliovirus enter through mouth and remain present in the intestine for a long period causing minor symptoms of fever or no symptoms at all in most of the polio cases. In only very few numbers of polio infected individual's poliovirus spread to human central nervous symptoms impacting the spinal column and resulting in development paralytic polio and sometimes death. Apart from this Horstman and Flexner discoveries were scientific breakthrough which set the foundation for development of polio vaccine to conquer poliomyelitis.

Although the growing scientific understanding progress settle much of the scientific uncertainty surrounding the unknown dreadful poliomyelitis disease among the general public. It was assumed that conquering poliovirus was easy and quick through development of preventive methods such as vaccines. However, polio vaccine development was not quickest path to be sought. Finding cure of polio disease was still a distant dream for many contextual and operational reasons during that era.

Despite discovery of poliovirus, modes of its transmission, pathways of its entry in human and technical methods to the culture poliovirus in laboratory setting. One of the fundamental operational problems was funding of laboratory-based polio research. Lab based

polio research was required with highly refined scientific resources and large number of monkeys exported from other countries. Thus, polio research was expensive and in dearth need of strong financial support to sustain the momentum of scientific progress made so far to understanding the poliovirus and find its treatment and cure.

The number of patients requiring polio treatment and rehabilitation also increased between 1900 to 1930s as polio epidemics increased worldwide. For many of the polio patients it was very difficult to afford the long term and expensive polio treatment and rehabilitation cost available at that time. After the World War I polio as a disease became a policy priority by epidemic effected countries. It was consciously recognized by many countries that growing number of polio patient need to be supported with necessary health care services as well as research studies to prevent poliovirus from spreading. Because of the large requirement of funds and its acute shortage with the governments especially after the World War I patient care was given more focus against the polio research activities. Subsided polio patient care was given more priority for treatment and rehabilitation of disabled polio patient to give them the necessary support to deal with the disease. In order to find means to bridge the huge funding gap. Many countries advocated for non-governmental means and sort help from private foundations for donations and fundings to meet the acute shortage of funds for rehabilitation and treatment of polio afflicted patients and polio research work progress.

It was the United States which took lead in organizing major polio fund raising campaigns and funding polio research work. As the incidence of polio epidemics increased during 1920s and 1930s afflicting many people with paralytic poliomyelitis. Observing large number of polio disabled patients and increasing frequency of epidemics, a general conscious was developed among the public and medical community to support the polio patient and polio research work. The momentum built to fight the deadly polio disease and its epidemics became

a national agenda in US. Everyone from public to government recognized the urgent need to do something fruitful to fight the dreadful disease and its paralyzing consequences.

By the mid of twentieth century the United States major polio fund raising campaign was organized under the then president Franklin D. Roosevelt. President Roosevelt was very famous and was himself afflicted with polio disability in 1921 before becoming president of US. In 1927 one of the largest polio rehabilitations centres in the US was opened by him named 'Warm Springs Institute for Rehabilitation' in Warm Springs of Western Georgia providing physical therapy and rehabilitation to a large number of polio patients.

It was during President Roosevelt administration after 1933 that polio became a national agenda in US. During his presidential years, from 1934 every year a large nationwide fund-raising campaign was organized on his birthdays, January 30th to raise funds from society to fight against polio disease. Roosevelt became the ideal candidate for these fund-raising drives as he was himself afflicted with polio disability and was working towards conquering polio under his presidential years. These fund raising campaigns were called 'Presidents Birthday ball' and a President Birthday Ball Commission was formed for using the collected funds effectively.

These fund-raising campaigns attracted massive funding from the public for this national cause. One of the reasons for surge in contribution for polio funding during Roosevelt times was because polio epidemics impacted the lives of general public in many ways. Citizens were not only frightened from this dreadful and devastating disease. But also compassionate towards polio patients and their families. Polio was a disease of national interest and everyone empathized with the paralyzed children with lifelong deformities. Polio fundraising campaign

also used posters with images of paralyzed children walking with steel braces to generate empathy among general public for generous donations.

The success of the President's Birthday Balls laid the foundation for the National Foundation for Infantile Paralysis (NFIP) in 1938. The NFIP was headed by Mr. Basil O' Conner, a very close friend of President Franklin D. Roosevelt. The NFIP was the first-ever private foundation in the history of polio, whose primary purpose was to focus exclusively on a single disease. The organization was renamed 'March of Dimes'. The organization initially worked with volunteers on organizing a fund-raising campaign across the country to raise funds for the fight against polio and managing the funds. March of Dimes across the nation was very successful in raising a significant amount of funds and was hugely supported by private philanthropies and the general public.

As the March of Dimes branched out across all the states in the US, raising a significant amount of money. Initially, the foundation focused on funding and provision of polio patient care and hospitalization, and public health education campaigns to educate the general public on polio disease and ways to deal with it. Because of the continuous flow of large funds to the foundation sooner, it became a prominent leader in supporting a large number of polio patients with expensive treatment and rehabilitation medical care services. It was later only that the foundation focused on funding polio research work and made the US a dominant leader in polio research work in the world.

There were several contextual factors which prompted the United States of America to take a leadership role in polio research. After World War I, although polio was recognized as a policy problem by governments of several countries shortage of funds remained a problem to support polio patients with expensive polio treatment and rehabilitation. In this context, polio

research was not given much priority over patient care who were unable to afford the expensive medical care services.

Polio research work in laboratories was very expensive similar to patient care. It was also the period when providing a large sum of funding to a single disease by any granting organization was not considered appropriate. Funding was very restricted for polio research work from the 1920s to the 1930s, from funding agencies. Funding available from a large number of universities and private research institutions was not sufficient to fund polio research activities. Even the largest private organizations, such as the Rockefeller foundation was, providing limited funds and were not able to adequately to fund the expensive research work of polio disease. It was clear to many scientists that polio research work is expensive requiring advanced laboratories facilities for a longer period of time. Considering the shortage of funding opportunities to carry out uninterrupted research work for a very long period of time. The two World Wars also disrupted and stopped many scientists research work. Many scientists had no option but to switch to other scientific research areas and stop the polio research work.

It was important to support polio research investigation to conquer the disease. After the World War II the momentum to support polio research work was built again. There was universal concerns to strengthen polio research work among general public and governments. But for a very longer period of time acute shortage of funds significantly delayed the important investigations on nature of disease and ways to develop its vaccine. It was considered equally important to strengthen the polio research work and give it equal importance as polio patient care.

No more delays were accepted in scientific progress in the field of polio which was essential for answering some of the unknown question around this devasting nature of the

disease. After the World War II European countries were not in the capacity to sufficiently fund polio research work. It was in this contextual environment that NFPI in US became a leader in the polio research work and later vaccine development. March of Dimes fund raising campaign were very successful in generating a large sum of money. The NFPI was in the position to not only sufficiently fund polio research work. But also means to generate more funds through its March of Dimes fund raising campaigns.

As a private foundation NFPI had already established itself at the world level as the one of the leaders in funding and support polio care and rehabilitation. The foundation expands its organization objectives and focused more on individual aspects of polio disease. This shift in NFPI focus was guided with the strong intention to dominate the global flight against paralytic polio. The foundation aimed to expand its role from just a granting agency to establish itself as chief strategist on polio vaccine related decisions. Thus, much later work of the foundation was focused on supporting laboratories-based polio scientific research work and to find methods for prevention.

The NFPI started its journey in the field of supporting polio scientific research work with addressing the problem of classifying polio strains. One of the prominent difficulties in developing polio vaccine before the scientists was multiplicity of poliovirus strains. There was a general consensus among scientists that to make any progress in developing active immunization against the polio disease it was necessary to first know all the polio strains.

Recognizing the general consensus among scientists NFPI undertook more prominent role to identify polio strains and provide some permanent solutions to progress in polio vaccine development. In 1948 NFPI started a project called typing program to collect and type all polio stains from across the globe. This was a unique project and one of the major research projects

endeavours in the history of polio research. But at the same time, it was not easy to implement a project of such a large magnitude expanded across the countries to type all the polio strains on this planet. The funding required for the project was much greater than required by any other scientific research project. For NFIP the project was an opportunity to establish itself as a global leader in the fight against polio disease in the world. It was not difficult for NFIP to start the project and provide large funds to complete the project. In 1951 within short period of three years of the start of typing project was able to collect and type across the globe around 250 poliovirus strains. Later the international committee to classify poliovirus under the typing project found that only three polioviruses' serotypes are infecting humans from a large family of polioviruses. The type I poliovirus was found more prevalent followed by type II and type III. By 1955 the international typing project was complete by the committee.

After the success of the typing project NFIP actively expanded its role as chief strategist in polio research work. The purpose of the foundation was to become a leader in funding, development and promotion of polio vaccine.

After successfully implementing the typing program the NFIP took a more prominent position in polio research funding and identifying methods for immunity against the poliovirus. A system of cooperative collaboration of laboratories for development and promotion of polio vaccine was established by NFIP. Under this system NFIP directly got involved in interuniversity laboratories research work on polio with supervision and funding role. It was innovative cooperative venture to fund interuniversity research focusing exclusively on a single problem. A supervision committee was formed for managing the funding, directing and strengthening polio research work in universities. Several of the scientists got benefited under the new cooperative system of NFIP. With support of NFIP major US laboratories were able to get long-term financial support to work on polio research studies.

One of the scientists whose research work caught attention of NFIP was Dr Jonas Edward Salk. Dr Salk was an American virologist at the University of Pittsburgh working on inactivated polio vaccine (IPV). The NFIP exclusively supported, financed and promoted the polio vaccine research work of Salk under the guidance of vaccine advisory committee of NFIP formed in 1953. Taking advantage of the series of scientific discoveries made in pervious centuries. In 1953 Salk used the methods of inactivated poliovirus with formaldehyde and cell culture technique to develop first inactivated polio vaccine. Salk discovery was a breakthrough in the history of polio research and vaccine development. He showed that the inactivated polio vaccine containing killed viruses was effective in protecting against poliovirus and producing polio antibodies in humans.

After the successful development of polio vaccine by Salk vaccine advisory committee accepted Salk method of inactivation of poliovirus and polio vaccine. The NFIP foundation expedited the process for large field level trail of Salk's vaccine, its promotion and administration to children. It did not take longer time for the Salk's vaccine to reach market after the ensuring its safety and effectiveness through largescale field trials started in 1953. After the success of two-year long IPV field trials, in 1955 it was announced to the world in a large gathering at University of Michigan's, that the first polio vaccine its ready for its use. No suspicion on efficacy, potency and safety of the polio vaccine were raised. It was found through field trails that 80 to 90 per cent of paralytic polio are prevented through Salk polio vaccine with good antibody formation to protect against poliovirus. Reassuring the safety of first polio vaccine all the speculative fears and anxiety around the polio disease and vaccine were settled among the general public.

After the media announcement of first polio vaccine its mass production was not delayed. In 1955 the vaccine licensing committee granted licenses to five commercial

laboratories to manufacture and distribute doses of Salk polio vaccine. The national wide vaccination program to inoculate children in US with first polio vaccine begin in April, 1955. But sooner the nationwide polio vaccination program was halted because many of vaccinated children started showing symptoms of paralytic polio. Within just fifteen days of media announcement on successful development of first polio vaccine and ensuring about its potency and effectiveness. The inactivated polio vaccine (IPV) and NFIP foundation became centre of criticisms.

In the early period of 1950s after the World War II many scientists put in the rigorous and continued efforts to develop polio vaccine. These lab-based experiments were done either using weakened or inactivated poliovirus to develop immunity against the poliovirus. Much of the polio vaccine research work was able to commence only within the environment of biomedical discoveries of the twentieth century. The scientific progress in the previous decades on understanding the nature of poliovirus, disease progression in humans and development of tissue culture technique facilitated the efforts to develop of polio vaccine. Although scientist in this environment were highly optimistic that it was possible to develop active immunization to fight against the paralytic polio and were putting lot of hard work to conquer polio. However the progress was very slow towards polio vaccine development. At the same time because of high media attention to lab-based experiments on polio vaccine development public expectations were increasingly very high. Public pressure with the demand to get quick results in preventing the polio disease were considered among scientist community not heathy for making any scientific discovery. It was a major concern among the scientists that this unwanted high attention and pressure could result in nascent and premature results acceptance. It would undermine the scientific rigor and quality of polio vaccine and would not leave much scope for its further advancement.

Unlike the Salk's inactivated polio vaccine other scientists research and development work on polio vaccine didn't get enough support from NFIP. The NFIP exclusively supported and promoted the Salk's vaccine and put in enormous amount of money for its research, field testing, and branding. After the successful discovery of Salk's polio vaccine, it was not surprising that NFIP didn't showed much interest in scientific endeavours of other scientists such as on live polio vaccine.

Among the scientists working on live polio vaccine was Dr Albert Sabin at University of Cincinnati College of Medicine and the Children's Hospital Research Foundation. Lack of support for testing the efficacy of live oral polio vaccine in the US, Sabin decided to cross the regional boundaries and test the live oral polio vaccine in Soviet Union (USSR) countries. It was a period of Cold War in which Sabin's polio vaccine got immense support for large scale field trails by Soviet Union scientists.

Salk's polio vaccine was used in USSR since 1957. But there was not much progress in reducing the number of paralytic polio cases among children in the region. Although there was declining trend in total number of poliomyelitis cases. But the overall decline in incidence was very slow and was considered very insignificant for conquering polio disease.

The problems with Salk's vaccine and availability of oral polio vaccine live strains donated by Sabin to USSR led to initiating nation-wide live oral polio vaccination campaigns at a mass level in 1956. Thus, much of the evidence on safety and efficacy of Sabin's oral polio vaccine for its use in other countries was reinsured by scientists in Moscow. The scientists of Moscow presented the findings on largescale mass oral immunization of population in their region at first and second live polio vaccine conference in 1959 and 1960. Using the evidence from scientific field trials using live oral polio vaccine and comparing it with efficacy of Salk's

vaccine the scientists of USSR ensured the world that it was possible to eradicate polio using the Sabin's live oral polio vaccine.

There were many problems highlighted with use of Salk's vaccine compared to Sabin oral polio vaccine. Sabin's live oral polio vaccine was highly supported by Moscow scientists. The epidemiological and economic advantages of Sabin's polio vaccine compared to Salk polio vaccine were particularly emphasized by scientists. Particularly speed of administering Sabin's oral polio vaccine. It was highly stressed by scientists that the promising oral polio vaccine could eradicate polio which is not possible with use of Salk's vaccine. Scientists ensured the world that Sabin vaccine can overcome many of the challenges encountered in using Salk's vaccine.

One of the aspects which cannot be undermined is that it was Salk's inactivated polio vaccine with set the optimism among the scientists, general public and governments of many countries that it was possible to prevent poliovirus and envision a polio free world. Discovery of Salk's vaccine calmed the public's fear and anxiety caused from the frequent polio outbreaks. But it was Sabin's oral polio vaccine which made it finally possible to conquer the fight against the paralytic polio. There were many advantages of using oral polio vaccine compared to inactivated polio vaccine. Although both the polio vaccine was capable to prevent the disease and produce immunity against poliovirus. But it was only Sabin's oral polio vaccine which gave the possibilities to launch a national wide mass polio immunization program with the vision to eradicate the poliovirus from the planet earth.

Some of the major differences between the two vaccines were. The Salk's vaccine prevents paralysis and produced immunity in vaccinated children against the polio infection. But it does not provide the population with natural method of inducing immunity and spread

of polio infection through faecal oral route. Thus, vaccine was not considered suitable to prevent new outbreaks and stop the spread of infection within the community.

Sabin's oral polio vaccine with weakened live polio viruses provided protection to children against the polio infection more than Salk's vaccine. The prolonged and immediate immunity with mild infection provided by Sabin oral polio vaccine compared to Salk vaccine negate the need for repeated booster doses. It was more advantageous for preventing occurrences of new outbreaks and only required a single dose during an outbreak to curb the polio infection. Two of the uniqueness of oral polio vaccine was passive vaccination and ease of administering vaccine to a mass population. The vaccine virus spreads from one person to another immunizing people. Also, vaccine virus multiples in the intestines of children several times. The excreted vaccine derived poliovirus through faecal matter and sewage protects people in contact with children. It ensured contact immunity by developing antibodies in unvaccinated children. Administering the oral polio vaccine was much economically cheaper compared to Salk's vaccine to manufacture and administer. Sabin's vaccine because of ease of giving it to children orally through mouth was much more acceptable to the community and children. It did not require use of needle, syringe and trained staff. It was possible to administered oral polio vaccine to a large population at much cheaper cost using wide human resources of unskilled people.

But the only major risk of using live oral polio vaccine was possibility of spread of vaccine derived polio virus within population causing paralytic poliomyelitis. This use of dead or inactivated polio virus in Salk's polio vaccine ensured much safety to population compared to live polio vaccine.

Polio vaccine using weakened polio virus administered orally had many advantages over the inactivated polio vaccine. The first live polio vaccine developed by Sabin was an innovation in vaccinology disciplines. The growing popularity of Sabin's oral polio vaccine and its widespread consideration for eradication of polio hugely impacted the national polio immunization program in epidemic countries. It contributed to change in polio vaccine policy in many epidemic countries including the US and later for the rest of the world.

It was never imagined in the history of polio epidemics not just one but two polio vaccines could make it possible to fight against the polio infection. Countries prone to frequent epidemics had to make a choice to choose between the two polio vaccines - OPV vs IPV. The development of live oral polio vaccine enabled the prospects for eradication of poliovirus in much lower cost compared to inactivated polio vaccine. There were several economic and epidemiological advantages for including oral polio vaccine in the national immunization program for the US and for other developed countries.

Since 1955 the US was using its first polio vaccine developed by Salk for polio vaccination. But within five years of its implementation in mid-1960s there was a major shift in US polio vaccine policy and Sabin live attenuated oral polio vaccine was included for nationwide immunization program. There were strong reasons which resulted in changes in vaccine policy in the US.

Salk's polio vaccine suffered a major setback after the tragic 1955 'Cutter Incident'. The vaccines doses injected from the Cutter Laboratories resulted in paralyses and death of few children. The Cutter incident was one of the worst human induced disasters in the history of polio vaccine. After the incident considering the safety of children IPV use was temporarily stooped in the US. There were many apprehensions on safety of IPV use among the government

officials and general public. Slowly the vaccine started losing its trust and acceptance within the population.

Although IPV was reintroduced in the national immunization program with improved safety protocols in later part of 1955 and was continued till 1961. But within this period despite the claims of government and public ensuring safety of vaccine general public showed least interest in taking the risk of inoculation. This reluctance to the first polio vaccine had its roots in the fear of paralytic polio which was very strong in the minds of general public. Parents of children willing to get their children immunized against the polio infection encounter a huge dilemma with the choice of IPV immunization. At the same time the health experts, public health officials and doctors had diverse views on safety and use of IPV and not fully support the use of the vaccine for public use. The resistance towards IPV was so strong among health experts that one of the prestigious medical association the American Academy of Pediatrics recommended to discontinue the use of IPV in the national immunization program. After reintroduction of IPV there were no reported cases of paralysis caused by vaccine use among children. But the overall environment of uncertainty on safety of IPV hugely impacted the prospects of use of IPV for a longer period.

It was not just Cutter incident that made Salk's polio vaccine less desirable of its continued use in the national immunization program. But for the long-term goal to eradicate polio which compelled the scientists, public health officials and the US government to switch to use of oral polio vaccine in 1961. There were many disadvantages of IPV and advantages of OPV for its choice and for eradicating poliovirus.

Salk's polio vaccine was not epidemiologically suitable for achieving the goal of polio eradication. There was sufficient evidence that Salk's vaccine was safe and effective. The

widespread use of IPV for seven years (from 1955 to 1961) after Cutter incident decreased the incidence of paralysis polio significantly in the US. But the vaccine was not able to break the chain of polio transmission within the community. In US polio epidemics were still occurring and infecting the children. It was widely recognized that IPV does not provide 100 per cent effectiveness even after three doses of vaccine.

Compared to IPV, live polio vaccine research and development was not limited to its experience in US only. Scientists and public health officials of many countries were involved in live polio research and field-testing studies. The Sabin's polio vaccine got wider support and was developed in a collaborative network of polio researcher from various parts of world. Much of the evidence on efficacy and limitations of live polio vaccine was widely discussed and accepted by range of experts in several countries. As a consequence, the Sabin's oral polio vaccine got immense publicity and wider support compared to Salk's vaccine.

The growing publicity of Sabin oral polio vaccine caught the attention of US scientist and public health experts. The success of the polio vaccine in dramatically declining the incidence of polio in parts of Soviet Union countries was politically alarming for US government in the Cold War period.

During the period of Cold War, the shift in the US polio vaccine policy was politically motivated. Also, there were several advantages of using Sabin oral polio vaccine for mass vaccination program which led to its acceptance in the US. The low cost to health service system for administering oral polio vaccine in mass vaccination campaign attracted the policy experts in the US. Further the Sabin polio vaccine was not just able to ensure long term protection against the poliovirus. But also, epidemiologically advantageous to dramatically reduce the incidence of polio cases enabling eradication of the disease.

Considering the epidemiological and economic benefits of oral polio vaccine and evidence of its remarkable success in Soviet Union region, the USA licensed OPV use and began its nation-wide use in 1963. In the US millions of children were easily given OPV in sugar cubes. From 1955 to 1979 the overall incidence per year fell drastically leading to elimination of virus completely.

Despite remarkable advantages of Sabin's oral polio vaccine for use in the national polio vaccination program. Oral polio vaccine was not completely risk free and safe. It was evident that use of Sabin weakened poliovirus vaccine could cause much larger damage in the form of vaccine derived polio paralysis in children. Oral polio vaccine risks were outweighed and OPV was given licensed in US and other developed countries. However other developed countries such as Scandavian countries and Netherlands continue using IPV for polio immunization and later successfully eliminated the poliovirus from their regions with longer immunity protection for their population.

2. Making Polio a Problem in Endemic Regions

Poliomyelitis as an endemic disease became a global problem only after the discovery of polio vaccines. Development of two polio vaccine generated the hope among people in epidemic countries to get protection from the polio infection. But it also set the intention to envision a polio free world achieved through eradication of poliovirus from the environment. Although both inactivated (killed) injectable polio vaccine (IPV) developed by Dr Jonas Salk and live attenuated (weakened) oral polio vaccine (OPV) developed by Dr Albert Sabin have their own unique advantages and disadvantages for conquering the battle against the paralyzing poliovirus. But with the discovery of polio vaccine the optimism to vision a polio free world was high for achieving complete victory against the polio disease.

As the polio vaccine became widely available many of the industrialized countries suffered frequent epidemics of polio in the past were able to control the transmission of poliovirus within their population. With decline in the incidence of polio transmission feasibility of elimination of poliovirus also became possible in many of the endemic countries.

With the success of many developed countries in global north, focus shifted to endemic countries in global south. Polio vaccine as a scientific tool was capable of ensuring complete eradication of poliovirus from the human society as it was achieved with small pox disease. At the same time one of the major sources of risk for reoccurrence of polio infection in developed countries was international importation of poliovirus from endemic countries. It was possible to initiate mass vaccination program for large population of endemic countries and achieve the goal of polio-free world. But polio was not a major public health problem in endemic countries.

Poliomyelitis as a disease showed dramatically different epidemiological characteristics in both endemic and epidemic countries. Although poliomyelitis was widely present in the environment of both temperate and tropical regions of the world. Before nineteenth century polio was endemic in nature. Poliomyelitis became epidemic in nature in temperate region's countries by the twentieth century. There were two epidemiological transitions in poliomyelitis in temperate region. Periodically frequent epidemics started occurring with characteristics of highly infection disease and with clinically recognizable symptoms. There was a sudden surge in number of polio cases with series of outbreaks of poliomyelitis starting in Scandinavian countries and simultaneously in the United States and in Europe. There was also change in age incidence of the disease. Poliomyelitis changed from a disease occurring in infants as infantile paralysis to infecting higher age group children and even adults. This unusual change in nature of poliomyelitis from endemic to epidemic and

change in age incidence gave the disease a visible recognition in the beginning of twentieth century.

There was no such pattern of epidemiological transition seen in tropical countries with sudden increase in polio cases with increased frequency. Rest of the world experienced endemic polio disease as observed prior to nineteenth century with sporadic cases occurring for a very long period.

The disease was considered mildly contagious or infectious and not a major medical problem. There was no doubt that polio was omnipresent with its sporadic occurrence. But for a much longer period of time worldwide distribution of polio in tropical countries was consider rare. It was during the two World Wars with occurrence of polio infection among army soldiers in tropical regions that endemicity of polio infection was clearer. Military units suffered polio infection in large numbers whereas the native population in the tropical countries remained unaffected with the infection. The incidence of polio infection among military soldiers negated the idea that polio is not a rare disease in tropics. In many endemic countries polio is highly prevalent with sporadic cases.

The knowledge on endemicity of polio infection in tropical countries also gave rise to the overgeneralized belief for some time that polio was exported from tropical to temperate countries. Particularly during the Second World War strains of poliovirus spread and resulted in epidemiological transition of disease to epidemic nature. This idea was sooner rejected as it could not stand the fact that worldwide distribution of polio was already known even before its epidemics started in developed countries.

But still it remained unanswered what were the factors which resulted in epidemiological transition of polio disease in developed countries in epidemic form. For much

later part polio remained as problem of advancement in sanitation and rise in living standards. In the developed countries major public health measures drive in the nineteenth century considerably improved the environmental and sanitation condition. Many of the infectious disease were reduced and level of morbidity and mortality declined drastically in these countries.

In the sanitized environmental condition, it was difficult to understand for scientists the occurrence of frequent outbreaks of poliomyelitis. Scientists were puzzled and were trying to understand why outbreaks of poliomyelitis occurred in advance sanitary environment in western countries. It was considered unusual for such epidemiological transition in developed countries whereas developing countries in tropical region remained unaffected.

In order to understand differences between nature of polio disease in endemic and epidemic regions studies were conducted various explanations were discussed among scientists at international poliomyelitis conferences. Prominent explanations which explained the endemic nature of poliovirus in tropical region was presence of immunity against poliovirus among children in developing countries. Children in developing countries were exposed to poliovirus earlier in life which enabled development of immunity against poliovirus. Primitive sanitary condition and crowded living conditions in underdeveloped areas gave children opportunity earlier in life to develop active immunity against poliovirus through exposure to subclinical or minor polio infections. Children also got passive immunity through maternal antibodies. Foreigners who were new to the environment of endemic countries are severely attacked by the polio infection because of the lack of necessary latent immunity.

This latent immunization was largely responsible for lower susceptibility to polio infection among the developing region children. On the other side children in developed

countries had very limited exposure to polio infection in early period of growing. Rise in living standards and advancement in standard of sanitation made the environment of industrialized countries mostly devoid of any disease infections. It had major positive consequences in the form of reduction in mortality and morbidity of many diseases. But at the same time this highly sanitized environment didn't gave children to develop latent immunity against polio infection. As a consequence, large percentage of children without any immunity were at very high risk of getting infected with paralytic polio infection.

Thus, it was largely considered for a longer period that problem of frequent epidemics of polio in western countries was largely consequence of the high living standards and advancement in sanitation enabling a clean environment. Poliovirus in temperate countries got a large number of individuals without any natural immunity to emerge in epidemic form. On the other hand, the poliovirus prevalent in the primitive standards of living in tropical regions did not get a large group of people susceptible to polio infection and remained endemic in nature.

For some time, evidence on sanitation and poor living conditions as key factor explaining the transition of polio disease in developed countries was accepted. But these explanations on presence of latent immunity and relationship to living standards were later refuted by Professor Albert Sabin. Although he acknowledged that there are differences in risk of paralytic poliomyelitis infection among people living in different regions of the world. But he argued mostly against the latent immunity explanation present among young children. Based on serological surveys evidence Sabin argued that low incidence of paralytic poliomyelitis seen among children in Africa, Asia and other underdeveloped regions population should not be attributed to maternal antibodies and to sanitary conditions. But the incidence of paralytic poliomyelitis is inversely proportional to extensiveness of poliovirus spread. In poorer regions

with suboptimal standard of living and sanitation the extensiveness of poliovirus spread is high and lower is the incidence of paralytic poliomyelitis.

The first step towards making polio a world-wide problem was reporting incidence of paralytic of poliomyelitis in different economically undeveloped endemic regions. Reporting the annual incidence and various virus types present in different regions was essential for not reporting purposes only. But also, for many other reasons such as to determine the source of polio outbreaks and thereby accountability of outbreaks, promotion and planning for public health interventions particularly for future funding and distribution of polio vaccines.

There was no major confusion of worldwide distribution of polio incidence since WHO started reporting of polio incidence in 1951. But there were major problems in reporting accurate incidence and prevalence of polio in endemic regions. Despite many studies been conducted to understand the incidence of polio and various virus types present in both developed and developing countries. The worldwide distribution estimates were limited to give any conclusive picture on polio incidence in the countries.

It was the year of 1953 which set the stage for international polio vaccination efforts. The WHO started putting polio as a major global public health problem with worldwide distribution. Not just as a problem of epidemics in western countries. Before global commitment to polio eradication much of WHO work was focused on efforts at the global level to report correct incidence of polio, promote oral polio vaccine and mass polio vaccination program in WHO regions.

World Health Organization in 1955 strongly stated in one of his reports that there were problems in reporting accurate polio cases across the countries. The official data collected on polio incidence was vastly varied in different countries. But also suffered from various

problems such as insufficient, underreported and incomplete in the underdeveloped regions. Because of the limitation of collected statistical data required for estimating the official morbidity and mortality for polio. The actual estimates of incidence of paralytic poliomyelitis remained unknown for a very long period in endemic countries.

It was in 1955 when interest to measure incidence of polio cases in undeveloped countries was developed within WHO. As a consequence, series of comprehensive surveys were conducted which confirmed rising incidence of polio in developing countries of Africa-Anglo, Egypt. This increase in incidence was largely due to improved reporting. But it establishes there is increase in incidence of polio as seen in developed countries and polio is becoming a serious problem in endemic undeveloped countries.

As a first step to promote the polio vaccine and plan an immunization program in endemic regions estimation of incidence of paralytic poliomyelitis settled the earlier debates on nature of endemicity underdeveloped countries. This step made polio a problem in sub-tropical and tropical countries and promoted the agenda of contemplating on implementation of vaccination program.

Over the past two decades before setting the global commitment to eradicate polio in 1988 world attention was gradually moved to polio disease as a major public health problem. Before the launch of global commitment to eradicate polio, efforts were made by international community to make insignificant problem of polio in undeveloped regions a significant problem.

In 1969 as part of International Health Regulations adopted by WHO at the Twenty Second World Health Assembly, members of states were asked to report complete data on polio

cases and outbreaks regularly. From 1970 WHO started publishing annually *Weekly Epidemiological Record* providing a summary of polio status across the world.

With increase in reporting the severity of polio epidemics in endemic countries also increased. This expanded the geographical scope of the paralytic poliomyelitis and made it a public health threat in underdeveloped endemic regions.

By 1970s discussion on continued rising trend of incidence of polio outside the western countries started. Various studies were conducted making the conclusion that polio is becoming a significant problem with increase in incidence such as Africa, Asia, Middle East and Latin America. The increasing severity of polio in Africa together with major outbreaks were widely reported. Thus, by late twentieth century regions which were considered polio-free earlier were put into the category of experiencing the transition of disease from endemic to epidemic.

But the characteristics of rising incidence of polio in endemic regions was not similar to temperate regions. Polio differs widely in terms of seasonality of increase in polio cases, not determined by seasons and age of incidence, occurring in children under five years of age.

Much of the later demand to conduct clinical surveys to accurately estimate polio incidence in developing countries began when Lameness survey was first conducted in Ghana, Africa. The rising trend in polio incidence in Africa attracted much attention to understand the magnitude of polio problem in endemic regions. Lameness surveys among school children were conducted in 1974 in districts of Ghana to study the impact of endemic polio in the rural districts. The published findings of Lameness survey established that paralytic poliomyelitis is a serious problem in developing countries and it is necessary to prevent and control polio in developing countries. The rates of polio incidence and prevalence reported from these surveys in rural Ghana were similar to rates reported during epidemic periods in developed countries.

Lameness surveys were considered useful for providing correct official data on magnitude of paralytic poliomyelitis in undeveloped countries and planning future polio vaccination programs. Following Ghana lameness surveys, more than 100 lameness surveys in undeveloped regions were conducting since 1974 to estimate the accurate polio incidence. The WHO facilitated these surveys and developed standards and protocols for reporting the survey's findings.

These Lameness surveys set the foundation for promotion polio eradication commitment later. Lameness surveys in Ghana and other areas contradicted the earlier held assumptions that paralytic poliomyelitis is a rarity among sub-tropical and tropical countries of underdeveloped regions populations and made it a significant problem. Also demanded for prioritizing countrywide polio immunization program. It also negated the prior hypothesis on inverse relationship of polio incidence with standards of sanitation.

Polio became a public health threat in developing countries in the latter half of twentieth century only, as prior to this period poliovirus was endemic with sporadic cases. Significance of lameness surveys in underdeveloped tropical region were highly regarded for accuracy of the data collected. As a result, lameness surveys were further pushed for collecting reliable data for planning future polio immunization program in endemic regions.

One of the obstacles to prioritizing immunization program in endemic regions was presence of latent immunity among young children and its relationship with poor living conditions in underdeveloped regions of the world. But lameness surveys strongly challenged this generalized explanation and made polio a serious problem for consideration prioritization of immunization in endemic regions.

Lameness surveys made the polio a serious disease in many of the endemic regions and put into the category of major public health problem. But it took more than a decade to considered the goal of polio eradication by the world community.

3. Conceptualization as a Global Problem

Within the World Health Assembly there was an environment of apprehensions and skepticism on considering eradication of diseases as a global health goal particularly after the failure of series of eradication efforts, particularly malaria eradication program. It was only in 1980 with the success of smallpox eradication program hopes and enthusiasm to set global eradication goal was restored.

But the commitment to eradicate smallpox and its success didn't came easily. Although the World Health Assembly in 1959 took the resolution to eradicate smallpox. But for a very long period smallpox eradication was ignored and efforts to immunization moved slowly until mid of 1960s.

Despite the availability of smallpox vaccine and technical feasibility of implementing immunization program at much lower cost compared to ongoing malaria eradication program. More emphasis was given to global goal of malaria eradication program and smallpox campaigns were considered needless and uneconomical by the World Health Assembly members of states. Members of states felt more focused should be given to malaria eradication program and there was no need for international support for smallpox disease as the disease is only a regional level public health problem. The reluctance of World Health Assembly to consider smallpox campaigns was put aside in Eleventh Health Assembly in 1958 when the goal of eradication of smallpox was reintroduced by USSR Deputy Minister of Health Victor

Zhdanov. In 1959 World Health Assembly passed the resolution to eradicate smallpox in next ten years.

But the efforts put in by WHO and its members states were insufficient to eradicate the smallpox. The smallpox campaigns were given less priority at WHO office in Geneva compared to Malaria eradication program. The goal of eradication of smallpox was considered unrealistic to be achieved in ten years period by many WHO member countries. There was lack of coordination and collaboration among countries and international agencies for the program. The much-needed international cooperation for the global eradication goal came when the USA in 1965, which made commitment to support the program in endemic countries of Africa. Thus, progress towards eradication moved very slowly until 1966 when the commitment to intensify smallpox eradication was taken at the World Health Assembly. Intensification of smallpox campaigns provided the much-needed boost to the eradication efforts worldwide.

From 1967 with intensify smallpox eradication implementation efforts towards the program was finally taken seriously both within WHO and in its member countries. In May 1980 smallpox disease was declared by the World Health Assembly as the first disease to be eradicated in the world.

The victory over smallpox disease eradication was significant as it came after long history of failures of single disease specific eradication efforts in the past. But more essential was how smallpox eradication program build a legacy for envisioning future eradication programs. The story of polio eradication program is built on the crucial lessons learned from success of smallpox eradication.

Smallpox eradication program provided the training ground for gaining field level experience to better implement future mass immunization and eradication program. The

smallpox program was a first program to show the significance of coordinated universal efforts to achieve a common objective. This universal global effort was something not undertaken in pervious health programs and eradication of disease efforts in the past.

Some of the important lessons learned from which restored the hope in implementing immunization program with the ultimate goal of eradication of the disease were – importance of universal standard approach and strategies, sufficient budget, uninterrupted supply of vaccines and other equipment, value of international collaboration for common public health goal, effectiveness of strategies of mass vaccination, outbreak control and relevance of a robust surveillance for measuring the program continued progress and identifying its gaps.

It was smallpox vaccine developed first by Edward Jenner in 1796. But it was Salk polio vaccine which started an era in vaccine equity. Vaccines became a public health good in 1955 immediately after the Salk polio vaccine announcement when America declared that the first polio vaccine in America will be administered for free to all its children. This initiative by American government was guided by the objective to ensure equity in vaccine coverage particularly for children who could be left behind due to inability to pay.

This was the beginning of unfolding of global momentum for ensuring equity in immunization. Compared to developing countries before the launch of smallpox eradication program many vaccines were widely available at relatively cheap cost in industrialized world to prevent childhood diseases. But it wasn't true for developing countries where extensive use of vaccines was rare.

Smallpox eradication program not only restored the lost hope that it was possible to achieve eradication as a common global goal using mass vaccination campaigns. But it also gave ground level experience that it was possible to deliver vaccines to the remotest regions in

the world together with the local and international support for achieving maximum vaccine coverage. After the success of smallpox eradication program there was great enthusiasm to make benefits of vaccines accessible to all, particularly the children in the world.

Success of smallpox immunization campaigns regenerated enthusiasm to develop a global immunization program and deliver the vaccines to the world population to ensure that benefits of vaccine preventable disease are provided to all. Although the legacy of Smallpox eradication made global use of vaccines possible and build the global momentum for ensuring equity in vaccination program. But there was no motivation among the global health community to commit to the goal of eradication of disease with the use of vaccines similar to smallpox eradication. The global commitment on global polio eradication program came more than a decade after smallpox eradication. As a public health strategy eradication of disease was not taken with great optimism by the end of 1970s and early 1980s. It was a period for a new international economic order. More emphasis was given to increasing inequalities across the countries and among population and ways to improve health status in developing countries.

Equity in health became the major theme of the period. Vaccine preventable immunization program became the foundation to promote equity in health worldwide. After the appointment of Dr Halfdan Mahler of Denmark as WHO director-general in 1973 international momentum for ensuring equity in health was built and Expanded Program on Immunization (EPI) was launched in 1974. Learning from the decade long successful experience of smallpox immunization campaigns in making smallpox vaccine accessible to the underdeveloped regions of the world. The World Health Assembly decided to launch EPI as an establish integrated system to deliver vaccine against a range of vaccine preventable disease according to the epidemiological situation in the countries. Following the legacy of smallpox

eradication program resolution for EPI as a next logical big step for global expansion of its role in its countries was taken at Health Assembly.

After smallpox eradication EPI for the Health Assembly was another opportunity for global expansion of its role in its member countries.

Thus, building of the legacy of smallpox eradication program EPI was developed as a national immunization program to make vaccines available accessible to all the children in the world against childhood diseases. This gave a major upliftment to development of national immunization program integrated with general health system in developing countries.

Smallpox eradication campaign already built the necessary ground level administrative and technical system and infrastructure to deliver the vaccine to children across the world. It would have been easy for EPI program to implement vaccination program to any part of the world. But despite availability of vaccines and necessary resources, the dream to make immunization possible for all children across world to prevent death and disability of young children of the world wasn't easily possible.

The EPI program started a new era in which vaccines were viewed as simple low cost-effective public health tool to deliver basic health services to population. Much of the work was needed to be done by WHO to promote the EPI to its members countries and generate sufficient resources to fund the program and its implementation.

After the launch of EPI, WHO promoted to the world community extensively the model of immunization to prevent childhood diseases in developing countries. Further to promote EPI and intensify its implementation Thirteenth World Health Assembly committed to the goal to reduce the childhood vaccine preventable disease by 1990.

It took more than a decade and a lot of work to commit to global polio eradication goal particularly to make eradication of polio as a major goal for the endemic countries. The EPI was a major step before the launch of polio eradication goal. But before global commitment to eradicate polio, major push was given to immunization of children as a goal.

Primarily because it was also a period when equity in health was the main focus of WHO. Mahler was passionately working towards the equity in health goal. Major event to boost the equity in health agenda of Mahler was the call for Alma-Atta conference in 1978. The Alma-Atta conference was outcome of Mahler's dream to ensure that equity in health provision of primary health services is accessible to all the populations of the world. At the Alma Atta conference primary health care (PHC) approach was extensively discussed and Health for All by the year 2000 was accepted as the goal.

Under the equity in health theme there was no scope for considering single disease specific short term disease control program and campaigns for eradication of disease. The WHO director Mahler first priority was provision of basic primary health services all people across the countries. Mahler was passionate for ensuring equity in health worldwide and was strictly against the short disease campaigns and building of large expensive curative services as a means to provide health services to population in developing countries. But in decade of 1980s Mahler's dream of providing primary health services as first necessity to people was severely challenged.

The popularity gained by the comprehensive primary health care approach soon turn out to be an approach which was gained recognition as to be too broad, idealistic, lack feasibility to implement and required unreasonable time period. One of the major arguments against the primary health care was lack of resources to achieve the goals of PHC. With this

recognition there was rise in Selective Primary Health Care (SPHC) in 1979. Against the expensive and unrealistic to achieve primary health care approach Selective Primary Health Care (SPHC) approach was promoted as an alternative to low-cost intervention model to ensure equity in health.

With the increase in momentum of selectivity cost-effectiveness and package of services became the foundational concept for designing public health interventions. Major shift was seen in child care and child survival program. In 1982 James Grant executive director of United Nations Children Fund (UNICEF) launched "child survival' campaign (later was rename as child development) with the aim to achieve universal childhood immunization by 1990s. Under this initiative UNICEF launched GOBI later known as GOBI-FFF (Growth Monitoring, Oral Rehydration, Breast Feeding and Immunization [from six vaccine-preventable childhood killers: tuberculosis, diphtheria, whooping cough, tetanus, polio and measles], female education, family education and food supplementation). These vertical programs of UNICEF were designed to directly attack infant and child mortality indicators.

The UNICEF established vertical child health programs which uses simple low-cost medical technologies to prevent the early childhood infectious diseases and reduce the rates of morbidity and mortality among infant and young children. Package of health services together with low cost requiring less financial and human resources giving high returns also motivated the donors for financing the health programs.

But Jim Grant *selectivity* in the delivery of health care services was diametrically opposite to Halfdan Mahler comprehensive primary health care approach which involved collective action. Alma Atta conference was jointly organized by WHO and UNICEF and both the international organization committed to the goal of achieving Health for All by 2000. But

the momentum of selectivity in the delivery of health care services as health equity model to promote Health for All goal made comprehensive primary health care model more unrealistic and less interesting. Thus, approach of selection of health priorities to promoted Health for All goal delivering only specific health services was considered necessary for reducing the mortality and morbidity indicators in a given population.

This resulted in developed tensions between directors of two largest organizations in global health - UNICEF and World Health Organization. The differences between the two large international health organization were more specially difference in - vertical versus horizontal approach in implementing health programs.

Mahler believed that delivering health services for only specific diseases based on estimation from mortality and morbidity patterns in a particular region would fragment the actions required to build primary health services. This was reflected in his address to Thirty - Sixth World Health Assembly in 1983 where he critically pointed that the selection of health priorities approach adopted by UNICEF as “Red Herrings”. For Mahler UNICEF’s approach was against the singleness of purpose as decided earlier at Alma Atta collectively by WHO, UNICEF and its member countries for achieving Health for All goal. Health for All was a collectively agreed goal by all the member countries. Mahler emphasized that this fragmented action in international health is top down and agenda driven. It not only diverts attention from Health for all goal of member countries.

But also takes away the sovereignty of countries to make decision for their national health affairs on their own and be self-reliant. Commenting on the fragmented international interventions taken which were against the collective health policy agreed by countries. He pointed out that this approach has failed in the past and failure of this approach was the only

reason which led to developing the primary health care approach. Humbly requesting for working towards the collectively agreed goal by all the member countries. Mahler pointed the need to learn from the failure of this approach in the past and warned against the negative influence of selective approach taken by international agencies.

Mahler critical comments on UNICEF was indirect attack on Jim Grant approach of isolating elements of primary health care approach overlooking the broader approach to ensure equity in health goal. Despite this UNICEF didn't change its approach and continued with promoting its GOBIFF project in developing countries.

Between WHO and UNICEF, the two large organization the apparent tussle with each other was because of selective and vertical approach taken to achieve equity in health by UNICEF. Despite critical comment by Mahler, Jim Grant did not change his new strategy adapted to prioritize selected health services for children needs over primary health care approach in countries. It was also a period after the World War II which gave rise to many bilateral and multilateral agencies with the objective to provide aid to poor countries and thereby increased their influence at the country level. By the early 1980s role of multilateral and bilateral organizations influenced increased not just within the global health activities. But also, within the country level health affairs and policies formulation. Thus, apart from WHO and UNICEF there were many other actors within the global health community working towards their organization interest and agenda. In this global environment with multiplicity of global actor's vertical approach guided by selection of priorities in developing countries for health intervention was more favoured against building the infrastructure for developing integrated primary health care model.

Mahler in his subsequent addresses to the World Health Assembly discussed the strategies for health for all goal, its monitoring and managerial framework for implementation in member countries. But despite Mahler passion towards working for comprehensive primary health care through cohesive and collective action. The global health environment was largely skeptic against building integrated primary health care model. There was uncertainty among many international global health actors on developing the necessary global cooperation for achieving universally defined goals under the Alma Atta Health for All strategy. The multiplicity of international agencies and differences among them was deemed difficult to overcome to build international cooperation among international agencies for a common purpose. Although Mahler largely disagreed that it was difficult to achieve cooperation for primary health care goal. The then global health environment was not encouraging towards Mahler determinism to take a more balanced approach to delivering health care services in developing countries. Mahler repeatedly attempted to promote primary health care comprehensive model, negated the belief on its impossibility and called for adherence to the collective health policies agreed by countries against the fragmented approach taken by international agencies.

Mahler felt weakened within the global health environment where isolating elements of primary health care was seen as a more cost-effective strategy. He remained very critical towards the top-down approach taken by international agencies to implement health programs where people outside of the developing countries priorities the health needs of people and overlook the other aspects of overall health of the population.

The period of 1980s was a paradigm shift in which immunization program given major importance for achieving the goal of equity in vaccine coverage worldwide. Immunization

program got major acceleration both under primary health care approach and with rise of selective primary health care approach.

Among the UNICEF vertical child health campaigns child immunization got major support and was promoted as one of the most cost-effective public health interventions. World Bank later in investing in health report, 1993 also promoted child immunization. Thus, immunization programs with aim to make available and accessible to vaccines to underdeveloped regions was gradually established as a means to promote equity in health worldwide.

Achieving global cooperation among international agencies was not difficult for initiating immunization program. Within the global health environment consisting of diversity and multiplicity of global actors' immunization programs were more appealing as they were cost effective, produced tangible and measurable results. Getting funds for the mass immunization program for whole of the population in the country was not difficult as many multilateral and bilateral organization were enthusiastic to provide aid to countries.

An era of equity in vaccine coverage through focus on immunization programs for the next decade became the central theme for all the major decisions and changes taken by the global health community. As the global momentum build ups to ensure equity in vaccine coverage immunization programs was widely discussed at various forums and major decisions were taken for improving immunization coverage in developing countries.

The EPI program was designed and implemented by the WHO member states aligning to the comprehensive primary health care model to deliver routine immunization services as an integrated service with the general health services and not as a vertical program. But the progress was very slow in achieving maximum vaccine coverage by members countries. The

need to accelerate the EPI program by the World Health Assembly was recognized and at the thirty fifth World Health Assembly in 1982 major resolution was taken to provide immunization for all children of the world by 1990. This resolution was taken in alignment to goal of achieving health for all by the year 2000.

Under this resolution great push was given to increase the effectiveness of national immunization programs at the country level by WHO. Member states of WHO were strictly asked that to achieve 1990 immunization coverage goal it was essential to restore the EPI activities based on five-point program discussed at health assembly. One of the major elements of five-point program apart from improving the administrative and financial structure of the EPI was to promote EPI within the context of primary health care.

The major impetus given to EPI by the Health Assembly in 1982 was further accelerated in 1984 at the Bellagio conference called by Rockefeller Foundation centre. Amidst in the environment of confusion and uncertainty on seeking international cooperation for collective health goals. The Bellagio conference was distinct as it was successfully able to bring together diverse international agencies and stakeholders from around the world and thereby bridging the gap in international cooperation. The common interest which brought all members of the conference together was the need to for protecting world children against the childhood diseases through vaccines. It was an initial meeting of donors to accelerate the global immunization campaign.

The conference papers were presented on serious situation of childhood mortality and morbidity indictors in developing countries, progress of EPI and current challenges for acceleration of EPI. Extensively discussion was made on strategies to improve immunization within the primary health care to achieve the goal of 1990.

At the conference through WHO EPI director Henderson it was pointed out that almost after eight years of EPI implementation in developing countries vaccines were widely available compared to earlier era and there was major improvement in management and delivery of vaccines to children. But vaccine coverage remained less and was still not sufficient to prevent deaths of children from childhood vaccines preventable diseases. Only commitment to 1990 goal of WHO members countries was not enough to improve immunization services. Many key challenges remained to provide immunization services as part of primary health care in developing countries.

The WHO developed the basic standards and protocols to effectively implement the immunization program. But sufficient funds for the EPI activities was significantly lacking. Strong emphasis was given at the conference to the need of accelerating EPI program efforts and funds its activities to be able to achieve the 1990 objective. Strong appeal for contributing towards the EPI program funds was made to the donors emphasizing the cost effectiveness of immunization program.

Emphasis was also given to deliver the immunization program integrated to primary care services. Integrated immunization services facilitated greater management and utilization of immunization and other basic health services to the community. It also addressesed the problems of infections and malnutrition among children.

The Bellagio conference was able to successfully put a plan to immunize all children fully by 1990 in developing countries through integrated immunization program with primary care services. But also recognized and promoted the need of oral rehydration, child spacing and family planning as effective methods to decreased the existing morbidity and mortality in developing countries among children.

Much of the later work on accelerating EPI efforts to achieve the 1990s goal of protecting the children of the world was done by task force on child survival as a not-for-profit agency. The need of a task force to facilitate immunization program activities ascended because of the disagreements between two large international organization WHO and UNICEF. Because of the ongoing ego classes both the agencies had problems in getting together sometimes and working together.

Before the Bellagio meeting at Italy both Jim Grant and Halfdan Mahler met with WF Foege former CDC director at a private meeting. Confessing their ongoing ego conflicts between them and recognizing the need of effective immunization program for ensuring child health. A proposal of task force headed by WF Foege was put forward by the directors of UNICEF and WHO to facilitate the immunize programs work for achieving the 1990 goal. The proposal of task force was put forth at the Bellagio conference by Jim Grant director of UNICEF and was unanimously was accepted by all the participants of conference.

The task force was small, informal, anonymous, private group to initially consisting of only three former CDC professionals and supported by Rockefeller foundation, UNCIEF, the WHO, the United Nations Development Programme and the World Bank.

As a temporary agency its major purpose was not to coordinate and compete with the agencies part of coalition. But only to facilitate immunization program work. But within a short period of time the popularity of the task forced increased and it distinctly was known as one of the prominent agencies to championing the goal of equity in health. It was not only successful in coalition five diverse international agencies to work together for a shared objective. But also, within six years of its formation was able to achieve global commitment of reaching larger number of children with at least one vaccine by 1990.

Within the environment of equity in vaccine coverage through EPI it was Rotary International (RI) established and funded immunization programs in many countries. It also dreamt of eliminating polio from human population extensively promoted and advocated the goal of eliminating poliovirus across and within countries through Rotary Clubs.

It was Rotary dream to eliminate polio. As the global momentum for ensuring equity in immunization was increasing Rotary organization uses it to promote organization mission. As a non-profit organization Rotary became a champion of equity in immunization goal.

Rotary International (RI) within short period of time of its formation in 1905 expanded the its role through Rotary Clubs. The organization work expanded to humanitarian services. Rotary clubs expanded from city to city focusing on projects which serve the local community needs. The work which began at addressing the community level local challenges at national later expanded internationally focused on addressing world needs.

Rotary humanitarian project started with rehabilitation of children with disabilities. Ensuring outstanding achievement, the "crippled children's work" gave Rotarians a sense purpose to raise funds and help children and their families.

In just twelve years of its formation rotary further expanded its work to addressing world problems and established an endowment fund in 1917. It was in 1979 that Rotary dedicated its focus for one year exclusively to needs of children aligning with United Nation's International Year of the Child year. Expanding rotary work to larger international level focusing on needs of children of the world Rotary decided to focus on specifically on worldwide immunization of children and adults from 1978-1980.

This decision of Rotary was consistent with its 75th anniversary in 1980. The vision of the board of rotary was to work at outstanding level for anniversary something which agency

hasn’t done before. For this purpose, the 3H program (Health, Hunger and Humanity or 3H) was formed. The program was centrally funded administer by a new 3H committee.

As the 3H program had broad vision and its wasn’t possible for any Rotary club to fund its projects. The board of RI decided to fund only a single large-scale project under 3H and later incorporate more projects. It was essential for 3H program to make a distinct image in international projects.

Immunization of children was something in which many rotary clubs were already involved and gained significant experience in conducting the program. Considering major support for immunization program within the organization the it was decided to focus on a special project on immunization as part of 3H program.

It was not clear which single disease to focus for immunization. After getting suggestion from closed associates of Albert Sabin in 1979 rotary board set the goal to eradicate poliomyelitis and alleviate its consequences. Setting the goal of eliminating polio initial plan was to use the funds of 75^{th} anniversary fund for just to immunize only one country. The first country to get funded and supported by Rotary for polio immunization project under 3H was Philippine. The Philippines lacked funds to include polio vaccine in ongoing national immunization program. The five-year polio immunization ambitious demonstration project of Rotary was launched in 1979. The success of the was enormous within just six months of its start and was able to cover larger number of children with polio vaccine by mid of 1980. Philippine’s project was set as model for 3H polio immunization projects. Many other countries asked for support of Rotary and the project was expanded to many other countries.

The ambitious polio immunization project under 3H program was successful and Rotary gained significant administrative and management experience.

Rotary endorsed its vision to work with other agencies with the aim to immunize and eliminate polio disease in 1980. It was also decided by 3H committee to set a date for eliminating polio disease. Working for the hundredth anniversary in the year 2005 with a vision to go beyond current goals of rotary. Immunization with polio vaccine was on the priority list of 3H program committee and many of the Rotary Clubs also supported the proposal to immunize children with polio vaccine and eradicate polio by 2005. Thus, goal to eliminate polio in every country by 2005 and protect the world children as part of its hundredth anniversary.

Although the goal was very ambitious the Rotary committee didn't consider the same. For the committee it only required sustained and expanded efforts for achieving the polio elimination goal. Within the environment of uncertainty on how funding for this ambitious project will be done it was believed by committee that to ensure polio vaccine coverage in developing countries availability of fixed grants per year would be sufficient. Thus, with rough estimates of its funding the proposal of eliminating polio was accepted by RI directors.

The board of Rotary adopted in 1982 the goal to provide polio immunization integrated with EPI to protect the world's children with the target deadline of achieving it by 100th anniversary in the year 2005. The 3H committee planned to involved all the Rotary clubs in every country for achieving the worldwide goal of polio elimination. All the clubs and districts were encouraged to work in collaboration with EPI program of WHO and other national and local level authorities for immunization of children against communicable disease.

Polio immunization supported by Rotary was an integrated services delivered under the WHO EPI program. But later when Dr Carlos Canseco was chosen as president of RI in 1984, he made strong opposition to existing Rotary strategy was made and put forth the proposal of

adopting the strategy of intensive mass immunization campaign. Canseco considered that under EPI program vaccine provided by RI to countries are wasted. Rotary president strong support to mass immunization program was because of his close association with Albert Sabin in the past. Canseco strongly pursued the 3H committee on efficiency of intensive mass immunization campaign giving children polio vaccine in a single day. But rotary members were skeptical on accepting Canseco proposal. Also, Rotary organization had no technical expertise to propose and help in initiating national immunization days (NIDs) in countries. The national immunization days (NIDs) were considered to be effective in eliminating poliovirus in low immunization coverage countries. But Rotary still needed technical information before even promoting mass immunization strategy for polio elimination in its funding countries.

Rotary to know the technical feasibility of national immunization days participated at the International Symposium on the Control of Poliomyelitis in 1983. But at the conference no conclusive agreement was reached on use of mass immunization as a strategy in developing countries. One of hindrance to adopting this strategy was of non-availability of basic infrastructure in many developing countries for polio. Rotary also didn't got discouragement from EPI director Henderson and WHO director -general Dr Halfdan Mahler who were not very supportive of mass immunization campaigns for polio vaccination.

Not having enough technical knowledge on feasibility and effectiveness of national immunization days Rotary members decided to promote both mass polio immunization strategy and integrated EPI model of WHO for polio immunization in its funding country.

But president Canseco was strongly against the EPI model and asserted on his vision of using mass immunization strategy in rotary funding countries. Canseco later also was successful in pursuing WHO to endorsing this vision. In 1984 rotary international set up

consultative committee to review the potential for global efforts to eradicate poliomyelitis. Following the meeting in 1985 Rotary International launched polio program with the goal to eradicate poliomyelitis by 2005. Rotary committed to fund US$ 120 million for the programme. This was the first and largest internationally coordinated private sector support for any public health initiative.

It was soon realized by the Rotary members that achieving this goal by the hundredth anniversary is impossible. There was no clear plan of action on achieving this goal and consequently many directors and trustees gradually didn't support the Polio 2005 goal under 3H program. So later in 1984 the name eliminate was change to plus in the program where the plus reflected the inclusion of other communicable diseases also. Rotary remained committed to PolioPlus program and funded countries without using the world eliminate.

The legacy of Rotary International in polio immunization was already built with rehabilitation of children with disability in its early days of formation. Later the Rotary took global leadership role in polio eradication.

For Rotary as an organization polio program was consider as an opportunity to make long lasting impacts thorough their efforts. It was not difficult for Rotary to promote and implement polio vaccination with its large network of Rotary clubs in each state and district in the world. Rotarians showed a sense of purpose and commitment to the global goal of to immunize the children of the world under its PolioPlus program.

But Rotary dream of eliminating poliovirus gradually set the stage for global efforts. Before the global commitment to eradicate polio, an environment was built to make commitment to global polio eradication goal feasible. By 1971 international surveillance of polio and reporting of outbreaks was made mandatory in WHO region member countries.

Many countries in developed countries had already shown to the world the effectiveness of mass vaccination campaigns for controlling poliovirus. During the period of Cold War, it was Eastern European countries which laid the foundation of polio eradication in the rest of the world later. Hungary implemented the first nationwide polio vaccination campaign using the Sabin polio vaccine strains followed by Czechoslovakia. The Czechoslovakia use of live oral polio vaccine made the country first in the world to eliminate the polio disease in 1960 much before the US success in eliminating polio in 1979.

In developing countries, the efforts to implement mass polio immunization campaign similar in Eastern European countries was first initiated by Cuba. There was no global momentum to implement polio immunization campaign by this time in developing countries. Cuba influence by the success of Czech decided to replicate the polio immunization campaign in 1962 based on Czech model. By the year 1962 Cube became the first country in PAHO WHO region to successfully eliminated the poliovirus. As the first country in the developing region of PAHO Cuba success was highly appreciated in the history of polio elimination. It significantly influenced other countries in Latin America region and in other developing polio endemic countries in the world.

Cuba polio elimination strategies of National Immunization Days (NIDs) using OPV implemented twice a year and house to house strategy was later became model strategy extensively used in other countries for polio elimination.

Although continuous use of oral polio vaccine has generated enough evidence on possibilities of poliovirus elimination in developed and few developing countries. There was still much skepticism on the feasibility of polio eradication. This was evident 1983 International Symposium on Poliomyelitis Control was organized by Pan American Health

Organization (PAHO) and WHO at Washington, DC. Despite extensive discussion on the possibility of eradication versus control of polio among polio experts and health ministers from around the world including two polio vaccine developers Salk and Sabin. The symposium researched at no general agreement on use of mass immunization strategy in developing countries and feasibility to eradicate polio.

Technical problems in detecting wild poliovirus and lack of political will among countries were the two factors which made countries reluctant to commit to polio eradication goal. Thus, polio was considered not feasibility after smallpox looked in twentieth century as there was no universal conscious on feasibility of polio eradication.

Despite the effectiveness of oral polio vaccine and mass immunization strategy it was not until the year 1985 that possibility of eliminating polio from the world again became the centre of public health discussion. There were only two prominent organization which were very supported of polio elimination from the world - Rotary International and Dr. Ciro A. de Quadros of Pan America Health Organization (PAHO), WHO region for Americas.

Inspired by the success of United States of America and other countries in eliminating poliovirus, in 1985 PAHO committed to eradicate poliomyelitis from the region by the year 1990. As a first regional commitment to eradicate polio the PAHO decision attracted much attention from across the world. PAHO commitment challenged the already existing dilemma on feasibility of eradication among polio experts. It was in 1991 one year after the target deadline that PAHO became the first region in the world to eliminated poliovirus and in 1994 acquired the status of polio free.

As a WHO region PAHO success had many significant influences on global polio eradication commitment. PAHO success model in eliminating polio was used to rally support

for global goal of polio eradication from WHO country members and donors. The PAHO success was used as evidence to endorse commitment to polio eradication to the members of developing countries.

Much of the concerns on initiating polio eradication in tropical endemic regions of the world were refuted by the success of PAHO region. The experiences of Latin American countries and strategies laid to eliminate poliovirus in the PAHO region were later adapted for global polio eradication. Thus, the foundation of polio eradication was laid by the PAHO region for rest of the world.

After the success in eliminating poliovirus in some of the most under-developed areas of Latin America. Possibility to envision a world free of polio were very high compared to previous decade. The path for global commitment to polio eradication was considered easy as the effectiveness of oral polio vaccine and strategies to eliminate poliovirus world-wide was already proven. The war against the poliovirus particularly in socio-economically underdeveloped countries was not considered difficult.

The elimination of poliovirus from American region laid the foundation for eradicating polio from the rest of the world. After a review exercise to assess the possibility of poliovirus elimination in other five WHO regions in the year 1988 commitment to eradicate poliomyelitis was taken. The Forty First World Health Assembly in 1988 passed a resolution to eradicate the poliomyelitis by the year 2000 and certification by 2005.

Global Polio Eradication Initiate (GPEI) was launched as the one of the largest international collaborations to eradicate poliovirus. Four key organizations World Health Organization, Rotary International, US Centre for Disease Control and Prevention (CDC), and United Nations International Children Emergency Fund (UNICEF) worked in collaboration

with ministries of health in each country to make the dream of polio eradication possible by 2000.

Long term efficacy, ability to break the chain of the polio infection, capacity to provide alimentary tract immunity to prevent re-infection, ability to provide additional immunity to close contacts of vaccinated person, lower cost of vaccine, ease of orally giving the vaccine by untrained staff were some of the advantages of Sabin oral polio vaccine which made it vaccine of choice for global polio eradication by WHO.

Oral polio vaccine was included in the list vaccine preventable diseases for its worldwide immunization under EPI program. After the global polio eradication commitment in 1989 a plan of action to accelerate polio immunization efforts was promoted by WHO. The goal was set to achieve 80 percent polio immunization coverage in each district for countries to achieve polio eradication.

But sooner the EPI routine immunization system was considered not fit to achieve the global polio eradication goal in many countries. Under EPI polio immunization efforts were just to control the polio disease prevalence and not to eradicate the poliovirus.

The global plan of action was revised and mass immunization campaigns were promoted by WHO for achieving the polio elimination by the decided deadline. Limitations of EPI for achieving the polio eradication set up a separate national polio immunization program in each country. Four-point strategy borrowed from Latin America consisting of National Immunization Days (NIDs) routine immunization, effective surveillance system, mopping-up campaign was promoted by World Health Assembly in 1995 for successfully achieving the goal of polio eradication. The vertical program model for polio eradication included supplementary immunization (SIAs) as the core strategies in countries for immunizing children

against poliovirus. The goal of polio immunization strategies under national polio immunization program was to ensure maximum coverage of children with oral polio vaccine and reach the last child with vaccine to achieve elimination of poliovirus.

Global polio eradication initiative (GPEI) in WHO regions was widely promoted as gift from twentieth to the twenty-first century. Social benefits of eliminating poliovirus for children across the world and effectiveness of the four-point strategy were at the core of campaign to motivate countries to start national polio immunization program. Government of each country was globally committed to eradicate poliovirus by the year 2000.

Global Polio Eradication Initiative was one of the largest after smallpox success. After the global commitment for polio eradication, it didn't take much time for the diffusion of polio eradication goal and strategies in developing countries. The activities to promoted and implement national immunization program in countries dramatically accelerated from 1988 to 2000. The international diffusion of polio vaccination program was from American PAHO region to other countries. But later south to south diffusion was prominent. The process of diffusion of polio eradication and its adaptation happened very rapidly where within the span of a decade many countries in the global south adapted the global poliovirus goal and initiated the process of its implementation. In the South East Asia Region (SEARO) countries after countries adopted the polio eradication goal. Cross national sharing of policy ideas, strategies, and synchronization of NIDs with other neighbouring countries were some of the prominent components of SEARO eradication efforts.

The WHO sustaining the international momentum built in favour of global polio eradication played a crucial role in endorsing the polio eradication strategies in its member states through its regional organizations. In the polio endemic regions of WHO each country

was supported with funds and technical knowledge to implement national immunization program. Main emphasis was given to strengthen the surveillance system to effectively identify poliovirus transmission and enhance the immunization capacity with focus on improving the planning, training and supervision and evaluation of immunization program in countries. Particularly countries with low polio vaccine doses coverage were majorly focused for improvements to ensure maximum polio vaccination coverage.

For WHO the South East Asia Region (SEARO) was crucial for implementing the national polio immunization program and achieving the goal of elimination of poliovirus. The global success of polio eradication initiative depends on SEARO region because of two main factors - 1) the region comprises of largest population almost 1/5 of the world population, 2) The region was considered one of the major sources of risk of polio virus transmission to other polio free countries. The countries in the tropical region of SEARO began implementing NIDs in 1991 with Maldives first and from 1994 to 1996 every country in the region started the polio vaccination program.

By 1991 American region, the European region already eliminated poliovirus and the success of SEARO region with its largest population holds crucial importance for success of global polio eradication goal. China with the world largest population was already initiated the polio immunization program in 1990s and successfully eliminated the poliovirus by 1997. Thus, among the SEARO countries progress of polio immunization program in India with its largest population was pivotal.

India as the second largest population in the world was late entrant to start national polio immunization campaigns. India started the polio program in 1995 along with Bangladesh, Bhutan, Indonesia, and Sri Lanka.

But the polio as a disease was not considered a major public health problem in India until 1979 India adopted Expanded Programme on Immunization (EPI) in 1978 with the goal to make vaccines available to all eligible children and pregnant women by 1990. After one year in 1979-80 polio vaccine was introduced to the routine immunization schedule along with diphtheria, pertussis, tetanus, tuberculosis and typhoid vaccines.

Despite introduction of polio vaccines there was overall low awareness among people about vaccination including other childhood vaccines.

The awareness on polio vaccines along with other childhood vaccines remained low among population irrespective of education and economic status. Surveillance of polio infection in the country very poor. Information on accurate incidence and prevalence of polio disease was limited where the only source available was hospital-based surveillance, Central Bureau of Health Intelligence (CBHI). Due to high underestimation by CBHI national sample surveys using the lameness survey methodology of measuring residual polio paralysis in children were largely conducted to estimate accurate baseline epidemiological data for planning polio actions and measuring the efficacy of polio vaccine.

From various national and state level studies the general epidemiological characteristics of the disease showed that in India poliomyelitis was an early childhood disease with no increase in age of incidence. The wild poliovirus infection in the country was majorly affecting majorly children below two years of age and few cases reported in below one years of age children. Although estimated on the magnitude of polio remained highly controversial the national survey estimates reported that the disease was highly prevalent.

Age of onset of paralysis was less than one year of age in children and the risk of polio infection increases among two to three years of children than in infants. Polio paralysis was

majorly affecting legs of children and leading to death in few polio cases. Polio incidence was equal in both rural and urban areas. Male children compared to female children were more susceptible to disease. Children from lower socio-economic families were more susceptible to poliovirus. These children were also infected by other childhood communicable diseases highly prevalent in the localities where children reside. Treatment of the disease infected with polio infection was sought mostly local providers even before seeking care from hospitals.

The national program for the control of poliomyelitis administered polio vaccine to the targeted children during the routine monthly immunization sessions along with outreach immunization sessions. The goal was to control the polio infection with sustained level of high polio immunization coverage during the routine immunization. But after the introduction of the polio vaccine the coverage of polio vaccine remained significantly low for many years. It was only after second half of 1980s that the polio immunization coverage increased sustainably in many states and districts in the country. Sustained improvement in polio immunization coverage also reduced incidence of polio dramatically in many states and districts. But the variation in performance of polio immunization coverage extensively prevalent within and across states and districts in the country. During the early years of the program immunization surveillance suffered from regularity, completeness, and reliability problems. Despite efforts to strengthen the immunization surveillance gaps along with substantial weakness in surveillance of polio persisted in the country. Strengthening of surveillance remained a critical need for effective control of polio in states and districts.

Knowledge on polio disease and use of polio vaccine was not new in India. Before the start of national polio immunization program in 1995 substantial research on the epidemiology of poliovirus and efficacy of polio vaccine was already done. Scientists since the start of International Poliomyelitis Conferences had actively participated in the conferences and were

part of discussion and debate on polio epidemics and scientific progress in the field. Many independent research work both in laboratory and field studies was carried out by scientists working on polio to understand the identifying the strains of poliovirus, magnitude, risks factors, and efficacy of polio vaccine among the population in decreasing morbidity and mortality. Thus, even before the start of program in 1995 India already had collected sufficient scientific evidence through many indigenous studies on poliovirus and polio vaccine effectiveness in the country.

Efficacy of the oral polio vaccine questionable in the tropical climactic conditions. Through many studies conducted both in tropical and temperate countries it was undoubtedly evident that compared to temperate regions formation of antibody response of oral polio vaccine was low in the tropical region of developing countries.

The efficacy of the trivalent oral polio vaccine was extensively studied in the southern part of India. Substantial evidence on oral polio vaccine effectiveness was produced by the Christian Medical College. Serological studies conducted in the tropical climate of South India town of Vellore showed poor antibody response of oral polio vaccine in the hot climatic conditions. Poor seroconversion response among children was because of poor rates of vaccine virus uptake and not due to loss of potency of vaccine or interference of other enteric virus infections. Moreover, the oral polio vaccine failed to provide immunity against the poliovirus among children even after receiving three doses of vaccine. Provocation of polio through intramuscular injections of diphtheria pertussis-tetanus vaccine (DPT) on massive scale under EPI was evidently a risk for paralytic polio in children.

This failure of the vaccine was detected in 1960s and widely shared within India and with scientists of other countries. Similar findings on poor efficacy of polio vaccine was widely

published by scientist of other countries. But despite wide disseminated poor efficacy of trivalent oral polio vaccine in hot climate conditions compared to cold climate. Oral polio vaccine chosen as a vaccine of choice by WHO and was endorsed in the polio endemic countries in developing regions.

Efficacy of polio vaccine in the tropical climate of India was not found to be good to provide protection against the poliovirus to the children. Efficacy of polio vaccine in the tropical climate of India was not very promising. The failure of vaccine was evidently proven through research studies conducted in India. But this scientific evidence on epidemiology of poliovirus in tropical region of India and poor antibody response of trivalent oral polio vaccine was not considered during the early days of formulating the national polio immunization program in 1995. Trivalent oral polio vaccine was chosen National Immunization Days (NIDs) to provide protection against the poliovirus to the children and eliminate the poliovirus from India. Debates on the effectiveness of oral polio vaccine in tropical region and questioning on its use for mass polio immunization campaigns continued within the academic community in India and Internationally. It was only much later during the implementation of the polio eradication program in India and its repeated failure in northern region that the poor efficacy of was recognized and became part of polio strategy discussions.

Globally WHO has already stated in the early years of GEPI formation that EPI was not an effective means to achieve polio eradication goal by 2000 in the countries. In India the performance of the EPI program to improve the coverage of polio vaccine through routine immunization services continued to be slow in decreasing the incidence of polio in the country. Gaps in the EPI program generated to need of implementing the mass polio immunization campaigns in the country. Neighbouring countries of India and few countries in the SEARO regions already began implementing the mass polio immunization campaigns to achieve the

global target of eliminating polio by 2000. But the evolution of the eradication program in the country was lacking political will and strong leadership to initiate the program. It was not until 1995 that National Immunization Days (NIDs) became a policy agenda in India.

Apart from international diffusion several domestic factors played very crucial role in diffusion of polio vaccine and eradication goal in India. Strong need of NIDs in the country was expressed by a range of domestic actors in the country.

Consistent advocacy for the polio immunization program was done reputed medical institutions such as India by Indian Academy of Pediatrics, groups of pediatrics from Maulana Azad Medical College, Rotary International regional club members, and WHO SEARO organization. Since 1987 rotary clubs in India were working in collaboration with government of India under their polio plus project to deliver EPI integrated polio immunization in various states of India. Meetings of rotary clubs, WHO SEARO meetings and with pediatrics discussing and promoting the polio eradication agenda were attended by health ministers of states.

These interest groups at various forums and meetings emphasized the importance of polio immunization program within the country. Polio advocacy was primary focused to pursued the various government officials, political leaders and funders to build an environment in favour of initiating NIDs in the country. Environment was built during the early 90s discussing the need of new *pulse* strategy for polio eradication in India.

The Delhi government health minister headed by a medical doctor Harsh Vardhan set the stage for Pulse Polio Immunization in 1994 bringing the necessary political will to initiate the program. With no prior knowledge of polio eradication initiative and concern in problem of disability, the interest of health minister was gradually built through attending meetings and

discussions with interest group members advocating the need of NIDs in the country. Motivated with a more political interest then health interest Delhi health minister decided to launch a pilot study on polio immunization campaign in capital city of Delhi on October 2nd, 1994 on the occasion of birth anniversary of India's father of the nation Mahatma Gandhi. This date for the launch of polio immunization campaign was politically chosen. It was seen as a great political opportunity by the Delhi health minister as no other political party had done such a health program previously. In designing the pilot study, the country already had a decade of experienced of implementing the polio vaccine in the country under EPI. By 1990 when polio vaccine became available Indian Ministry of Health and Family Welfare officials already have a polio research studies data of nearly twenty years to guide the polio eradication polio decisions. Despite this much of the policy learning was taken from outside of the country from experiences of other developing countries such as Brazil and Philippines.

Consequently, highly motivated with this opportunity the Delhi health minister took personal efforts to make the launch of the program successful in the country. Before the launching of the first polio NID campaign in the country strong mobilization and advocacy was done by the health minister for the program among diverse community stakeholders and within the Delhi government for supporting the activities for its launch. All the state level ministries of government of Delhi were used for contributing to the planning and implementation of polio campaign. The program received unprecedented encouragement and participation from political parties, influential peoples, medical and non-medical staff, donor agencies and NGOs.

The pilot study successfully vaccinated millions of children up to age of 3 years with polio vaccine in a single day. The implementation of campaign received massive participation from across a diverse section of community.

Delhi pulse polio campaign became a model for replicating to the rest of the country. With the motive to leverage the political gains from the success of Delhi polio campaign the government of India in 1995 launched the Pulse Polio Immunization Days (PPIs) in three states Tamil Nadu, Kerala and New Delhi. Later in 1996 it was extended to all the states of the country.

4. India's Story of Many Failures and Successes Towards Polio Elimination

For India the National Pulse Polio Immunization Program (PPIs) was the first eradication program after independence and second global program after smallpox eradication. Although the government of India took up the challenge to ensure that the polio vaccine reached the last child of the country. India with is second largest population with varied geographical environment and diverse population groups the task of immunizing children with polio vaccine was daunting in many aspects.

One of the essential prerequisites of planning and implementing National Immunization Days (NIDs) was that it was a single day activity where all children from up to five years of age had to be administered trivalent OPV to interrupt the wild poliovirus transmission. The time restricted implementation of two NIDs conducted six weeks apart in large population such as India multiply to manifolds. Ensuring every child targeted under PPI was administered polio vaccine in two NIDs in Indian context means ensuring quality vaccines are available on time at more than five lakhs immunization posts (IPs).

This involved elaborated management exercise to mobilize resources, arrange logistics, mobilize community extensively and ensure every child is immunized in each NIDs. This elaborated and massive task of administering polio vaccines to millions of children in a single day was not done by any other country of the world.

After the adaptation and institutionalization of polio eradication in India the implementation of PPI program met with unprecedented progress. During the initial three years biannual NIDs implemented each year since 1995 resulted in substantial decline in number of reported polio cases in the country. India progress in short period of time was within the country was highly regarded as “extraordinary”. Internationally also the India progress was highly appreciated. Apart from consistency and rigorousness in implementing the global polio eradication strategy one of the distinguishable aspects of India progress from the rest of the world was that in every NIDs cycle India was attempting to vaccinate large number of children. India with its largest population was able to reach millions of children by 1998 with polio vaccine within a span of just three years. Subsequently the number of polio cases reduced and genetic biodiversity of circulating poliovirus types 1 and 3 reduced considerably.

India progress in the early days of the program success is attribute to simplicity of the program, volunteerism, high political commitment, and aggressive social mobilization. Gradually the awareness for the “Polio free India” goal was engraved in the minds of every people in the society. Similar visibility and popularity were not seen for other health programs implemented in the past.

Strong commitment from political leaders, providers and community contributed to increased visibility and popularity of the polio immunization campaigns within the short period of time. The program was established as a massive public health movement with the objective to achieve a common goal of polio free India.

The PPIs at the highest-level policy makers such as the prime minister, central and state health ministers’ secretaries was able to generate strong political commitment. The goal of polio free country was given high political priority together with optimal resources

investment. Similarly, providers of the program and utilizers of polio immunization, families and community were equally giving high priority to the program goal.

One of the uniqueness of India polio immunization campaigns was simplicity of the program. In the diverse socio-cultural and geographical environment of India simplicity of the program was prerequisite for ensuring better implementation of the program. Simplicity of the program was sought in terms of availability, accessibility, affordability, acceptability of the polio immunization program. The NIDs were designed in such a manner to make polio vaccination accessible with least obstacles to the community at their doorstep (1 km from homes at immunization posts), free of cost provided on holidays (Sundays). Both for program providers and community considered simplicity of the program as one of the key factors which helped in better implementation of program and its success during the initial days.

The simplicity of the program and the concept of people's program gave way to developing the spirit of volunteerism for NIDs implementation. The UNICEF & rotary organization with the objective to establish NIDs as people program contributed in mobilizing people from diverse section of the society to help in implementation of the program.

During the early days of conducting NIDs volunteers contributing to almost all the program activities from organizing immunization booths to raising public awareness for the polio immunization. These volunteers included people from varied sections of the society such as teachers, students, religious leaders, medical practitioners, community leaders, housewives. Intense social mobilization was key contribution of volunteers. Both awareness campaigns, public appeals, interpersonal communication before and on the day of NIDs was conducted to motivate parents to come to immunization booths for vaccination. Volunteers ensured children of their neighbourhood or relatives are vaccinated by personally bringing children to

immunization booths. School children rallies organized throughout the country contributed to raising awareness of NIDs and endorsing the goal of polio free India in both urban and rural areas. The NIDs were celebrated as a day festival across India.

Volunteers' personal involvement and strong commitment for the polio free goal contributed immensely to the better implementation of NIDs and increased the program popularity massively in short period of time. Spirit of volunteerism created enormous support and participation for OPV from families and community with least resistance. Volunteerism from diverse stratum of the society for implementing NIDs made the program visibility grow as a people's program.

Features of optimal program management, effective intersectoral coordination and aggressive social mobilization was given major emphasis since the start of the NIDs implementation. Formation of district and block coordination committees, decentralized microplanning and flexibility in program management at district and block level was central strategy for effective implementation of NIDs.

Since the beginning of the program intense social mobilization campaigns was focused as one of the key factors for success of the program. The purpose was to make sure that the global goal of preventing polio disability reached the last person in the country. Strong messaging was majorly central around creating 'fear of polio disability' among community to motivate the families for polio vaccination of their children.

Strong IEC messaging, media and interpersonal communication were effectively utilized to disseminating the program messages on goal of polio eradication, the disability caused by polio disease and benefit of program, awareness on general child health, and information on NIDs.

Not only health workers, NGOs and leaders participated in social mobilization campaign. But also, community members also took part in disseminating the messages of program and raising awareness about the program. The strategy of social mobilization campaign resulted in generating cooperation for the program activities from community. It also helped in community participation in implementation of program such as tracking of non-utilizers of PPI and contributing to other NIDs activities.

Strong political patronage to the NIDs also played a crucial role in increasing visibility the program and facilitating its acceptance among the communities. In the initial periods of conducting NIDs there was an increasing trend of families participating in every cycle of NIDs. The possibility of social resistance and social-cultural barriers among the families impacting the polio immunization campaign was negated because of increased participation of mothers. Positive attitude was developed among mothers where they perceived program both consumer friendly and high political priority. Absence of any signs of community fatigue was predicted from attitude of mothers bringing their children on their own to immunization booths.

Intersectoral coordination and community cooperation together with participation in NIDs were identified as compelling reasons the success of the program in the initial phases' success. Strong local political support and involvement of association of NGOs was essential program strategy of the program to bridge the gaps between community and program implementers. Non-health departments also helped in intense social mobilization campaign and managing the functioning of immunization posts on the day of NID.

But the initial period of success was not without reoccurring challenges to the implementation of the program. These challenges in implementing NIDs was identified by

program implementers and other stakeholders were communicated to higher authorities and measures were taken to rectify the problems by policy makers. Several of the problems encountered by implementers were because of weakness in the existing health service system capacity at the district and block level to make available timely and potent polio vaccine delivery to immunization posts for vaccinating children.

Majorly the program implementers at the ground level confronted problems of shortage of funds for social mobilization, lacked flexibility in spending unspent funds for other program needs, availability of transport facilities for movement of manpower and vaccine to immunization posts remained a reoccurring problem particularly in remote and hilly tribal areas. Potency of vaccines was severally impacted due to malfunctioning of cold chain equipment's and frequent shortage of electricity supply in the primary health centers. Opportunities to review and monitor post NIDs activities for improving implementation was given less importance and were negligible in most districts. Formation and functioning of district and block level coordination committee irregular.

Although since beginning of the program inter-sectoral coordination with other non-health department was considered crucial for functioning of the program. Particularly in the context where health service system in several regions lacked sufficient human resources to carry out enormity of the tasks primarily due to many vacant positions. But several challenges on involvement of non-health departments were faced. Majority of health workers and some district and block officers lacked clarity on the role of NGOs and local leaders within the program. General perception was developed that hat PPIs activities are responsibility of health department. Thus, non-health personnel passively participated in program activities perceiving they have no prominent role in program. Sustaining smooth coordination among non- health

department workers, NGOs and leaders and health workers, workers remained a difficult task at implementation level.

Several measures were taken to address the implementation level problems. Timely supply of polio vaccines for conducting NIDs was significantly improved over the years. Mobile teams were used for additional procurement of vaccines at several places. Recognizing the critical need of maintaining high potency of polio vaccine as an additional measure to monitor vaccine quality before administering it to children Vaccine Vial Monitor (VVM) were introduced. It also ensured quality and safety assurance of polio vaccine for skeptical parents.

Local state electricity department was coordinated as important partner for ensuring uninterrupted supply of power for maintaining cold chains and potency of polio vaccines. Problems in availability and maintenance of transport facilities was addressed. But despite these efforts' problems in management of transport facilities and difficulties in maintaining cold chains remained a persistent problem reported by program implementors. Despite training given to vaccine providers on use of VVM labels before giving polio vaccine to children. Most of the program managers, health workers, NGOs and leaders lacked clarity on use of VVM within the program and were not sufficiently skilled to interpret the VVM labels.

Measures were taken to improve co-ordination with non-health departments, NGOs and local leadership. Defining their role and responsibilities; involving them in planning and implementation; and acknowledging their inputs for efficient planning of program and their overall contribution to program activities. But maintaining sustained involvement and co-ordination with other non-health personnel remained a challenge within the program.

During the initial years of program implementation three major problems identified which impacted the program progress in later NIDs cycles were - missing of targeted children, early signs of implementation fatigue and community fatigue.

One of the major problems delaying the success in eliminating the poliovirus was missing large number of targeted children from polio vaccination within the program. The fixed immunization booth strategy was immunizing millions of children on each NIDs but missing 10 million children annually. This sustained the continued transmission of poliovirus within the community and possibility of future polio outbreaks. Concerns of continued missing of children in every NIDs round and difficulties in achieving task of 100 per cent polio vaccine coverage was strongly resonated by program providers. Tracking the inaccessible families was recognized a major problem since the beginning of the program.

Curbing the risk of poliovirus transmission was difficulty within the context where problem of non-utilizers grew with each NIDs cycle. Despite availability of IPs at the door step for certain category of populations the NIDs were still inaccessible. Factors preventing certain family's accessibility to NIDs were physical or geographical constraints and behavioural constraints influencing the acceptability of the program. Accessibility and affordability were significant factors for daily wages workers of various types, beggar and agriculture labourers and slum dwellers preventing their children from coming to immunization posts. Almost half of the non-utilizers of the NIDs were not aware of polio vaccine and its benefits. Among other half who were aware of benefits of polio drops and were willing to immunize their children. But were unable to come were people living in remote areas, migrants and tribal population.

Several pro-active efforts were made by program implementers from the very beginning at all levels to address the inaccessibility barriers to the IPs. Non utilizers were

identified and characterized and efforts were put to reach difficult to reach populations and removing the barriers in reaching IPs. Bringing children to immunization posts (IPs); giving polio drops at home; using mobile IPs team for immunizing; making facilities for availing immunization just a day after NID day or in the next regular routine immunization day, strengthening awareness and motivation of community were some of the proactive measures taken by program implementors to maximize the polio vaccination reach. These proactive measures taken by program implementors helped in developing a perception of a consumer-friendly program. This was resonated by most of providers, community members including mothers. Despite proactive efforts a category of small proportion of 'hard core' non- utilizer families who were not willing to give polio drops sustained. Acceptance of PPI was greatly influenced among these families because of strong socio-cultural and religious beliefs, bad experiences with the program in the past, negative rumours about the polio vaccines. News published by press and media was also negatively influencing the acceptance of program among community. Concerns were raised on by program implementers on restraining media and press from such news publishing.

Sending legal orders and other coercions were used as a measure to increase the acceptance of the program among hard core' non- utilizer families. But overall intensified social mobilization campaign was considered are needed to increase acceptability of the program among community and prevent utilizers from becoming non utilizers of polio vaccine.

Efforts to track non-utilizers families and additional efforts to resolve the problem of missing targeted children didn't make substantial progress. The proportion of missing children remained significantly high in every NIDs. The program needed to implement more innovative measures to maximize the polio vaccine coverage.

Repeated cycles of NIDs biannually each year together with unrealistic targets, extra work, increasing official pressure, lack of sufficient supervisory support and follow up and feedback mechanism were some of the early signs of implementation fatigue among providers at district and block level field staff.

As the program progressed each year repeated cycles of NIDs caused community fatigue. Early signs of community fatigue were apparent by the fourth cycle of NIDs. Families and community members started questioning the program implementation purpose for longer period. Particularly questions were pointed – how long will the program continue and why repeated polio drops are given again and again every year.

Despite intensive social mobilization campaigns and IEC messages of the program failed to communicate clearly on overall purpose of an elimination program and manner in which it will be conducted. The lack of clarity among families and community members on the purpose of repeated cycles of NIDs and rationale of giving repeated doses of polio vaccine to their children caused fatigue. Not only among community people but this clarity was lacking also among volunteers, health workers and teachers. Additional doses of polio vaccines were also misinterpreted at several places particularly by mothers - as a way to prevent other diseases, no need to immunize children with other vaccines under routine immunization, and providing overall good health for children. The need to reinforced social mobilization campaigns with short clear messages on reasons to give additional doses of polio was consider essential to curb the early sign of community fatigue.

The PPI program by the 1998-1999 cycle reached very near to achieving full immunization coverage, vaccinating larger of children with two doses of OPV. The polio program was considered to be in the final stages of eradication of poliovirus from the country.

India was taking a lead in the global polio eradication program. Success of polio elimination efforts of India were already praised internationally and anticipations were made for final elimination of poliovirus in the largest democracy. At the national level policy experts and government of India were not at all apprehensive on achieving the 2000 polio eradication deadline. Confidence to was high among the national stakeholders that India will polio free by end of 2000.

Despite substantial success and high confidence for achieving polio free goal intensifying the NIDs was chosen as a policy shift to achieve elimination of poliovirus. The fifty second World Health Assembly 1999 endorsed the plan of acceleration of polio efforts in endemic countries to achieve commitment of eradicating poliomyelitis by 2000. Following the WHO international directions technical consultative group (TCG) of WHO-SEARO decision to increase the number of immunizations rounds to six per year in the country was taken by the government of India.

The Pulse Polio Immunization program was renamed as Intensified Pulse Polio Immunization in 1999. The new immunization strategy was called 4+2 program include four National Immunization Days (NIDs) and two Sub-National Immunization Days (SNIDs).

Apart from international resolve to achieve the 2000 deadline at the country level in India the reason for increasing the frequency of NIDs was presence of large pool of unvaccinated/missed children despite efforts to immunize children via NIDs and routine immunization. By the end of 1998-1999 cycle India was considered to be in last lap of PPIs cycles. But the need of major policy shifts was considered essential to address the problem of missing children in each NIDs. Particularly low poliovirus transmission season (December and in January) from fixed IPs provided immunity for only few months creating an absence of

immunity in communities every year. Maximizing polio vaccine coverage was consider essential to achieve the 2000 global poliovirus elimination deadline.

Along with intensification of NIDs many innovative measures were taken to reach the non-utilizers of polio vaccine and increase the polio vaccine coverage. Giving polio drops at home for two days after NIDs was one of the proactive measures taken in earlier PPIs cycles by program implementers to reach non -utilizers and hard to reach populations. There were also apprehensions among government health workers that this strategy will make utilizers of PPI more passive and reluctant to get polio drops at IPs.

But from the earlier NIDs cycles it was recognized that immunization booth-based strategy was not sufficient to maximize coverage of polio vaccine. Change in delivery of polio vaccine was intended to not only reach hard-to-reach communities but also to improve quality of polio campaigns. House to house immunization strategy was introduced in 1999 to ensure complete coverage by identifying un-immunized/missed children at home and administering them polio drops. Along with giving polio drops at home marking of children received polio vaccines and marking of houses of non-utilizers by vaccination teams post NIDs was also introduced as innovative measures to ensure each targeted child is reached and to maintain quality of NIDs overall process.

Intensification of polio eradication efforts was an international decision adopted towards the final phase to globally to interrupt wild polio virus transmission in endemic countries where it was most persistent. This shift in polio eradication strategy to accelerate the NIDs were not guided by evaluation of program needs at the country level. But were specific directions given to all the endemic countries including Government of India by WHO to

accelerated polio efforts. Consequently, this policy change had many disadvantageous implications on the overall functioning of the program.

Concerns were already expressed by endemic countries on gaps in financial budget to implement intensified polio action plan at the WHA in 1999. As projected increase in frequency of NIDs together with implementation of SNIDs increased the financial budget and increased overall demand of OPV to endemic countries. Global shortage of OPV supply became a reoccurring problem in countries with increased NIDs rounds.

At the country level the continuous efforts were needed in every NIDs round to manage the problem of timely procurement of polio vaccines just to sustain the progress made in controlling the poliovirus transmission. The strategic changes made along with intensification of NIDs changed the nature of program from people's program to more institutionalized program with paid workers. The house-to-house visits extended one day polio immunization activity to several days. Consequently, this increased the planning and management activities enormously and increased in overall burden of polio vaccination exercise. The rigorous field-based activity resulted in dropping of many volunteers of PPIs activities as it required more time. Responsibility of planning, management and implementation of NIDs increased immensely health workers particularly frontline health workers. The increase in the NIDs frequency to six rounds along with house-to-house activity to be carried out after NIDs/SNIDs made program fatigue more common and reoccurring problem in sustaining the PPI progress.

The house-to-house strategy was covering missed/dropped houses out of NIDs. But was not sufficient to reach migrant and hard to reach populations. Further the quality of vaccination exercise through home visits and house marking improved only rural areas. But was lagging in

urban areas due to lack of sufficient workforce. Practices of over reporting of immunized children remained dominant despite introduction of finger marking.

With each repeated PPI cycle community fatigue and implementation fatigue became prominent. Depleting of enthusiasm among providers and community became a dominant concern in subsequent NIDs cycle requiring special attention at ground level.

The increase in intensity of booth-based approach along with house-to-house approach made the community fatigue more apparent. High intensity of NIDs along with weakness in social mobilization campaigns made community more reluctant to visit IPs. Because of house-to-house approach there was uniform decline in parents visiting the fixed IPs. As pointed by health workers in based on experience of earlier NIDs cycle. The house-to-house strategy made parents more lethargic and reluctant to come to IPs as they perceived that immunization teams will come to their houses.

The visibility of the PPI program as national commitment to global community to achieve polio free status inspired health workers. The enthusiasm to successfully implement the PPI program the overall polio vaccination exercise was very high among frontline health workers in the beginning. Despite the huge increased in extra work health workers were able to generate motivation and energy to carry out polio vaccination duties. Increase visibility and respect of the health workers within the community also influenced their motivation to rigorously work for achieving the national goal of eliminating poliovirus. Although increased in burden impacted their other primary responsibilities before, during and after NIDs. But with each repeated cycle of NIDs gradually the motivation and energy of health workers declined and overall program suffered from implementation fatigue.

Global polio eradication was a collective common goal. Success of a WHO region was not motivating for other countries and regions. But also determine the success of other regions as well. Consistent efforts were needed equally from all the countries in all the WHO regions to ensure reduction in poliovirus transmission and prevent poliovirus import to other polio free countries. Lagging behind of even one country in a region impacted the success other countries in region and overall success of the program in the WHO region.

South East Asia Region with its largest share of population in the world was essential for overall progress of global polio eradication. The ten SEARO countries collectively and gradually started implementing NIDs from 1988. But within the short span of a decade many countries reported last confirmed polio case. By 2000 all the nine countries in the SEARO region were able to interrupt the transmissions of polioviruses in 2000 except India. India missed the targeted 2000 global deadline and this delayed the progress of other countries in the region to achieve polio free WHO regional certification. It also increased the risk of importation of poliovirus to other neighbouring polio-free countries.

India was a late entrant among SEARO countries in launching a national pulse polio immunization program. Despite this within a short period of time India was able to achieve substantial success which was globally recognized and was inspiring for neighbouring Asian and African countries. The world was looking forward to learn from success story of India.

Polio policy experts acknowledged India progress in initial period as “extraordinary”. By mid of 2000 the progress was sustained with remarkable results. India was reporting lowest number of confirmed of polio cases since start of PPI in 1995. The surveillance system in India continued its high performance and steady improvement in accuracy of detecting poliovirus

and stool collection rate. By late 1999 transmission of type 2 poliovirus ceased and only types 1 and 3 were prevalent.

There was no dearth of confidence among national level policy experts on the strategies implemented in PPIs and with certainty they gave statements that India will end poliovirus transmission by end of 2000. But they were also conscious of the fact that the intensity and high performance of immunization activities are essential to achieve the success.

But despite this positive outlook among policy expert's poliovirus transmission in the country continued with cases still reported in many parts of the country. India became the only endemic country in the SEARO region not able to interrupt the polio transmission.

Globally by mid of 2000 it became certain that global deadline of achieving polio eradication has to be extended as many countries were still reporting polio cases. Region of Americas, European region and Western pacific region of WHO were already polio free by 2000. But the poliovirus circulation was not stooped in South East Asia region, Eastern Mediterranean region, African region. Despite extraordinary progress polio eradication program globally including in three remaining endemic regions of WHO. Polio was still crippling children in South Asia sub-continent, sub- Saharan Africa and parts of the Middle East. Seven countries in these regions (Afghanistan, Egypt, India, Nigeria, Niger, Pakistan and Somalia) remained endemic to poliovirus. More time was needed to by polio endemic countries to make the global polio program a success in their country. So, the deadline to interrupt the poliovirus transmission was extended from 2000 to 2002 and to achieve polio - free certification in subsequent years.

Missing the deadline of 2000 had major implications for the global polio eradication initiative. It was essential to sustain the motivation among donors, country ministers and other

stakeholders for the eradication effort. Fear of losing financial commitment of major polio funders and countries became a concern GPEI stakeholders. As a consequence, in 2000 at United Nations headquarters in New York meeting renewed commitment was made to achieve global polio free world by 2005 to sustain motivation among polio partners and countries. But this meeting was primarily called to reaffirm sustained global financial commitment for reaching the goal of polio eradication. Challenges in interrupting poliovirus in endemic countries and roadmap to strengthen the efforts through five -year strategic plan (2001 -2005) were presented by WHO to reassure donors achieving the goal of polio free world.

In India the PPI program became highly visible and successful by the end of 1998-1998 cycle. India rapid progress in the short period of time was accredited to strong commitment by politicians at all levels, strong commitment and sustained enthusiasm of implementers of program at district and block level; efficiency in management of NIDs, effective synchronization NIDs with other neighbouring countries and above all the enormous community support and participation.

During the initial years of PPI cycle the program implementers were able to generate intense participation from community, school children, teachers, local leaders and NGOs in the program. Participation of diverse groups from the community helped the program cultivating acceptability of the program and endorsing benefits of polio vaccination among population. The PPI was considered to have become a people's program by majority of stakeholders.

Rigorous external evaluation of the program in initial years and valuable feedback from agencies led to many important programmatic changes within the program. A number of innovative programmatic changes were taken to address the implementation level problems and improve the quality of NIDs process. House to house immunization, introduction VVM,

proactive efforts to identify and reach non-utilizers of the program, marking of houses and finger of immunized children. Increased sub-national immunization days were particularly focused to interrupt high polio transmission in few high-risk states and districts These strategies were considered sufficient by policy experts to completely eliminate poliovirus in the country by 2000 in all states of India.

But despite the unprecedent progress in the country India was not ready to call an end and declare the country polio free by 2000. Based on the earlier progress achieved hopes were high to complete poliovirus elimination soon before the new deadline. But it all depended on the intensity of polio immunization activity and improvement in coverage in the country. In India apart from problem in reaching the missed children and sustaining the population immunity. Confidence of national policy stakeholders since the beginning of the program was low in two northern states of India – Uttar Pradesh and Bihar. It was clear to policy experts by 1998-1999 NID cycle that India will be able to achieve targeted goal by 2000 expect in some pockets in UP and Bihar. These two states in subsequent NIDs cycle became a major challenge for achieving the polio free status in India.

Although the targeted deadline to interrupt poliovirus transmission was extended by two years. The global polio eradication program in the world was making substantial progress in reducing the share of total number of polio endemic countries. Extraordinary progress made in remining three WHO regions was accentuated globally. Hopes were high within WHO and among other global stakeholders that remaining WHO region will be declared polio free soon. In the new global polio eradication strategy, all the attention was on strengthening the polio eradication efforts in the remaining polio endemic countries within the three regions. All the global resources and funding were diverted to these remaining endemic countries including India to win the battle against the poliovirus.

Global pressure was immense on polio-endemic countries as only two years were remaining to achieve polio free world. Under this intense pressurizing environment, it was very crucial for India's national prestige to not only sustain the PPI program progress achieved so far. But also, to address the current challenges and achieve high performance in each NIDs cycle to achieve success by 2002 deadline.

In India polio was effectively controlled by 2000. There was continuous decline in polio transmission in low season along with decrease in biodiversity of type 1 and type 3 in the country. This epidemiological situation in the country gave hope to polio experts to be able to finish the job of ending poliovirus transmission in two years. For the next two years aim was to maintain the continued program achievements gained and subsequently maximize the vaccine coverage with determination to reach the last child with polio and make India polio free. But there were many programmatic and operational challenges to reach the last child in the country.

Major global obstacles to vaccinating the children of country and eliminating poliovirus was continued problem of funds and shortage of OPV doses. After the intensified NIDs strategy ensuring adequate and timely funds and OPV vaccines became a reoccurring challenge for successfully completing the NIDs/SNIDs on time within in the country.

Conducting NIDs/SNIDs in the large population of India every year was resource intensive and required timely availability of adequate funds. Micro- planning was one of critical resource intensive exercise for success of polio immunization campaigns. Continued pooling of financial resources and logistics support to implement micro plans in every PPIs cycle particularly in high-risk areas became a critical component for polio experts for ensuring successful implementation in the country.

Meticulous planning and management became a continued exercise before each SNIDs and NIDs to ensure that appropriate doses of vaccines are available from the vaccine suppliers for distribution in the country on time. In cases of delays of adequate supply of OPV doses focus was shifted to provide doses of vaccine first to high polio transmission states for each SNIDs. This was critical to control the poliovirus in the country and maintain the acquired immunity among children against the poliovirus transmission.

Another major challenge for India was varied performance of polio program in the country. Since the start of the program, it was certain that the endemicity of poliovirus and progress in PPIs was widely varied. Consistent with the global strategy at the national level all the attention and resources were diverted to stop the continued transmission in endemic regions in the country particularly in high-risk states.

The regional variations visible in program performance divided the states in the country first into the category of better performing regions and poor performing regions after 1998-1999 cycle and later in mid of 2000 after evaluation of intensified strategy into three zones based on intensity of polio transmission - high burden zone (HBZ), middle burden zone (MBZ) and low burden zone (LBZ).

After the implementation of intensified strategy, it was evident that the states of the southern region in the country were emerging as polio free. Focus was needed in the country to maintain population immunity and stop the transmission in states where intensity of transmission was low reporting one or two cases of polio. But the major challenge for the success of the PPI were states with continued intense poliovirus transmission together with dense population. These were the high-risk states with dense population and reporting maximum number of polio cases.

Some of the attributes identified of poor performing states from the start of the program were apathy of providers at all levels, lack of proactive efforts to improve and strengthen the program, lack of implementing the program strategies as per the standards, fewer changes in micro planning, fewer efforts made to strengthen intersectoral coordination in planning and implementation, inattention to logistical problems of transport, cold chain maintenance and gaps in human resources, falls or over reporting of targets achieved.

Apart from these problems weakness in the surveillance also became a major problem in poor performing states. High quality surveillance was one of the hallmarks of India's success recognized globally. The need of establishing quality acute flaccid paralysis (AFP) surveillance system was addressed very early in the program implementation. Since the beginning polio surveillance indicators in India achieved above the global benchmark level compared to other countries which achieved it after many years. But there were gaps in accurate mapping of poliovirus transmission and defining the extent of virus transmission in poor performing states. There were also gaps in adequate number of surveillance medical officers (SMOs) which was later resolved through additional appointment of SMOs in 2000.

Corrective measures were taken to strengthen the surveillance system. But the improvements in accurately defining the extend of poliovirus remained widely varied. Thus, along with addressing weaknesses in surveillance system it was imperative to strengthen the program planning and implementation in poor performing regions to successfully interrupt the poliovirus transmission in the country.

After 2000 it was clear that the continued and persistent transmission of poliovirus was limited to well defined pockets in country and in clusters within states. It was recognized that to stop transmission of poliovirus it was essential to reach each and every child and immunize

them with polio vaccine. For the next two year the end game strategy in the country chosen was house to house mop-up immunization. Resonating with the global strategy mopping up activity was introduced in beginning of 2001 at large scale across states with continued poliovirus transmission apart from SNIDs/NIDs. Particular the focus was on high-risk areas where poliovirus transmission is persistent.

But there were many challenges to success of mop up campaigns in the country. In the past practice of implementing low quality of mopping up campaigns in the country was prevalent in some areas. High quality of mopping up exercises was essential for reaching the targeted children in areas with persistent transmission of poliovirus to interrupt the transmission. The success of this strategy was important in high burden districts to avoid further delays in the entire national polio program.

Practice of low-quality mop ups campaigns was disadvantageous and damaging to the program and was highly discouraged by the polio experts. Recognizing the critical need of quality execution of mop up activity in the country to reach the last case of polio before 2002. It was considered urgent to eliminate inconsistencies and confusions in practice of implementing mopping up activity and reaffirm the core objective of conducting mop ups drives among program implementers. Mop up drives were resources intensive and repetition of this activity was a huge financial and human resource burden. Although strong measures were taken to ensure its quality particularly in high intensity polio transmission areas the results were very promising and sufficient to stop the poliovirus from infecting children of the country and prevent outbreaks.

India unprecedent progress was since the beginning of the program was differential progress. There was wide variation in intensity of poliovirus transmission across states. With

each subsequent PPI cycle the focus of national level polio policy experts increased on addressing the challenges in implementation of program in high-risk clusters of poliovirus areas. Every year fresh targets were defined to strengthen program and innovative strategies to address the existing problems in accessing the children. But with each passing year the enthusiasm to achieve polio elimination goal observed in the beginning of program implementation was depleting among providers and community.

By 2001 India was able to sustain the program achievements made so far with slight increase in total number of polio cases reported. One of the major achievement programs made since 1995 was steady progress in decrease in number of polio cases and shrinking of district with poliovirus transmission in the country.

It was clear to national polio experts that the interest and enthusiasm to achieve polio eradication by 2005 in the country is very low and major efforts are needed to sustain the interest of masses towards the program in coming years. As sub-optimal quality of SNIDs/NIDs remained a continued problem not only reported from high-risk states. But was also reported at many occasions from low poliovirus intensity states and polio free states.

The disadvantageous implications of implementation level challenges still existing by the end of 2001 on the program performance and achievement made so far was apparent in the following year. The low-quality implementation of PPI campaigns, complicacy and providers fatigue became major hinderances to program progress in subsequent cycles and resulted in major setbacks.

Two years remaining the global target it was very crucial for India to finish the job as quickly as possible. Remarkable aspect of India program achievements so far was that the poliovirus transmission was limited to few defined pockets within the country. The program

reached a stage where it able to prioritize its attention to only high burden areas and this was advantageous for program progress. Although it may seem easy to focus on strengthening program implementation in these poliovirus persistent pockets. But it was challenging to address the implementation gaps in these areas where poliovirus transmission was intense and caused by multitude of factors.

Two high burden states which became an impediment to achieving complete elimination of poliovirus and a significant risk to progress achieved in other states were Uttar Pradesh and Bihar. As these two states were recognized as endemic reservoir of poliovirus since start of PPI. The remarkable progress gained in the initial days of program implementation in the country has exceptions to these two states. The poliovirus had set it roots in these two poorest and densely populated regions in northern belt of the country. Emergence of these localized reservoir of poliovirus in the country became very prominent challenge in subsequent NID cycles for sustaining the overall progress of national program and to prevent the risk of introducing re-infection in other states of the country.

After 2000 failure to reach the global target of interrupting the poliovirus transmission. The overall focus of the program implementation was to address the gaps in implementation and strengthen the program in poor performing states. During this period a major setback struck the program progress. A major resurgence of polio cases occurred in high burden state of UP in 2002. The outbreak made state of UP and India a global concern. The WHO director general Dr Gro Harlem Brundtland issues a statement in 2003 declaring India and particularly UP as first priority for stopping poliovirus transmission globally. The state of UP made India a number one priority for ensuring global success of GPEI.

But it was not the first polio outbreak that occurred in UP. The state was prone to outbreaks before and after the start of the program in 1995. The state was reporting maximum polio cases every year and was major risk factor among endemic states since 1995 compared. All the poliovirus strains identified in the country after 2000 originated from UP. The state became a persistent endemic reservoir of circulating poliovirus in the country. The state of UP stand out as a major risk factor among other endemic states because it was spreading and infecting not only other states within India. But was importing virus to other border neighbouring countries and polio free countries in the past.

Success of the program in the state since beginning of PPI was not very promising. The state often caught media and press attention questioning the progress of program. After 2000 media reports widely reported the growing concern of failure of PPI program in Uttar Pradesh and Bihar. Since 1995 transmission of poliovirus was not once interrupted in these two states. The dramatic progress of PPI in southern states of the country was compared to northern states particularly in these two states. Thus, doubts were raised on success of program strategies and potency of OPV used in UP and Bihar.

Refuting the media reports and widespread discussion on failure of polio program in these two states the national level polio experts issued statements on progress achieved so far and reasons for sustain the optimism in the program performance in these two states. Decrease in number of cases and shrinking of polio-infected districts in the nationwide as well as in UP and Bihar post 2000 were seen as sufficient factors for denying any accusations on failing of program. Within UP state the areas of endemic reservoir of poliovirus were restricted to western part of UP. Few states in western UP (Moradabad, Rampur, Badauan) were prone to continuation of virus transmission reporting more than half of the polio cases in UP by 2001. Low routine immunization coverage among under-five children with three or more doses of

OPV was one of the prominent reasons considered by polio experts for delay in achieving the desired results in these states. Addressing the gaps in poor performance of routine immunization multiple SNIDs and pre- emptive rounds were conducted. The progress achieved so far in two states was sufficiently remarkable for program implementers and there were high hopes that with time similar progress as seen in southern states of the country will be observed in northern region.

The 2002 outbreak in UP was considered an outbreak of the decade because resurgence of number of polio cases in the state were huge resulting in India contributing more than 80 percent of cases

In 2002 conducive epidemiological conditions developed in UP and in other states which resulted in occurrence of outbreak not only in UP but also in several states across India. The continuous poliovirus circulating in reservoir areas of UP spread first to neighbouring states and other states across India. Immunity gaps against poliovirus in other states facilitated local spread of virus in some states and enabling re-introduced of virus in few states. The impact of the outbreak was more severe for program achievement made so far in the country as well as globally.

The state of UP over the years became an epicentre from where the poliovirus receded to the endemic pockets within the state when epidemiological conditions were non-conducive and spread to neighbouring regions and states when the immunity gaps were prevalent in other states. There were many factors which made state of UP a persistent reservoir of polio cases and global concern.

The expectation of polio experts to see last cases of polio in UP and Bihar by early 2002 failed despite implementing multiple strategies to strengthen the program. The deteriorating progress of the state of UP caused the 2002 outbreak.

At the global and national level major barrier to achieving high performance of PPI program in India and in UP was attributed to political apathy and lack of supervision of the health system activities. The state consistently lagged behind in immunizing all the targeted children. For the past several years in UP large pool of unimmunized/under-immunized children with OPV vaccine was a persistence problem. During the past years a number of factors made situation conducive for poliovirus in UP for its high intensity and its spread to other state were persistence high endemic transmission of type 1 and type 3 poliovirus in western UP; failure to interrupt poliovirus transmission in pockets of UP, large cohort of unvaccinated children in central and eastern UP creating the necessary immunity gap for resurgence of poliovirus and its spread.

Major operational level implementation gaps recognized by national level polio experts for resurgence of poliovirus in UP and its capacity to move out of endemic reservoirs to other states were - low polio immunization coverage and missing of large number of children in SIAs rounds and routine immunization, decrease in number of NIDs/SNIDs, deteriorating quality of NIDs/SNIDs, rising resistance of community towards PPI campaigns in western UP were some of the factors created the conditions necessary for outbreak of 2002.

National level policy decision of decreasing the frequency of NIDs/SNIDs after completion of intensified pulse polio campaign in 2000 greatly influenced the performance of the program in UP. Polio experts of India consistently scaled back large scale NIDs/SNIDs statewide from six rounds to three rounds (2NIDs/1SNID) by 2001-2002. Frequency of polio

campaigns was reduced to save on operational costs of conducting polio campaigns. Mop ups were given more priority as an end game strategy to completely stop poliovirus transmission including in endemic regions of UP and Bihar by 2002.

Despite the high performance of AFP surveillance system in India it failed to accurately define the high transmission of poliovirus and existing gaps in quality implementation in endemic districts of UP and in other states. Lack of vigilance and failure to accurately detect wild polio virus transmission on time particularly in central and eastern UP majorly contributed to occurrence of one of large outbreak in history of polio outbreaks in UP.

Intensified pulse polio campaign and failure to complete the program targets by 2002 exhausted the program implementers. Thus by 2001 compliancy and providers fatigue also became evident influencing the quality of implementation and overall program progress in the state. Despite giving high priority to quality in conducting NIDs/SNIDs within program implementation including house to house visit deteriorating quality of polio vaccination campaigns together with insufficient routine immunization coverage and missing of large number of houses post NIDs/SNIDs rounds became more prominent problem in several districts of UP. Insufficient participation of women and community members in vaccination teams, low community involvement in the program, inadequate supervision greatly influenced the quality of SIAs.

This situation in this densely populated state in the northern belt of India became very unique compared to other high burden states. By 2000 it was much evident that western UP is emerging as an endemic reservoir of poliovirus compared to central and eastern UP. Continued persistence of pocket of reservoir of polio virus in western UP along with high intensity of poliovirus was limiting the overall progress in the state as well delaying programmatic

achievements in the country. Considering the risk of western UP endemic pockets of poliovirus, the region was specially targeted by the polio expert at national level for implementing multiple SNIDs/NIDs, mopping up activities and high-quality routine immunization to stop remaining chains of poliovirus transmission by the year 2003. But at the situation at the ground level was opposite to what was expected and it failed to completely stop poliovirus.

After repeated PPI cycles interest and enthusiasm were wanning off not only among providers but also among community.

Community fatigue and developing of social resistance could greatly influenced the progress of polio eradication program in countries aiming for polio eradication. Recognizing the importance to build acceptance of the PPI program among community since the 1995 national level policy experts gave more emphasis to create a people's program. Innovative efforts were put in to provide more space for community involvement within the program and reduce any resistance. But repeated NIDs cycle and lack of clear communication to community on the overall purpose of repeated doses of OPV gradually build fatigue and social resistance among families and communities.

As community fatigue was apparent after completion of intensified polio immunization cycles. Particularly by 2000 the growing program resistance was acknowledged by the program implementers in poliovirus reservoir areas of western UP districts particularly from within Moradabad district. In the past social-religious and cultural factors were associated with large number of polio cases reported from western UP. Program resistance was common among families of marginalized communities. Nature of the resistance was majorly denial of polio vaccination campaign sometimes by whole villages due to spread of negative rumours about polio vaccines or events such as death of a child after taking polio drops.

But after the 2002 resurgence of polio cases, it was more evident that majority polio cases were reported areas densely populated with Muslim community. Majority of these areas were in urban and per-urban districts of western UP. More than 60 percent of polio cases were reported from Muslim community alone during 2002 outbreak which was disproportionately high as Muslim only constitute 18.5 percent of total population of UP which makes it second largest community in the state.

High intensity of poliovirus in these areas was sustained with very low immunization coverage among Muslim community. Majority of Muslim community children were under immunized received fewer doses of polio vaccine and were missed during SIAs and routine immunization. This created necessary immunity gap with large pool of unimmunized/under immunized Muslim children. At the end of year 2002 and 2003 the number of polio cases were still reported in large numbers above seventy percent. But the distinctness of these polio cases was that reported from young children particularly the children of Muslim minority community in UP. By 2003 it was distinct that a typical case of polio was defined as a Muslim boy child age less than two years.

As the transmission of poliovirus continued and sustained among the Muslim children after the outbreak. The past NIDs/SNIDs cycles implemented in areas of densely populated Muslim community in UP failed to reach and vaccinate young children from this community.

The community was seen as a major reservoir source of poliovirus infection in UP post outbreak. Participation of Muslim community in NIDs/SNIDs was low and were consistently missed from accessing the benefits of polio vaccine.

Innovative strategy of (SMNET) implemented in 2001 to reduce social resistance among community in western UP through strong behaviour change mobilization campaigns

was not sufficient to increase the community participation in the polio immunization campaigns.

It became evident post outbreak that using strong and effective social mobilization and communication program for engaging communities as well as providers was considered necessary not only for endemic areas in UP. But also, for sustaining the depleting interest of both community and providers in polio free states till complete elimination of poliovirus is achieved in the country.

In endemic areas of UP reaching marginalized underserved population of the society particularly Muslim community was difficult. But also, it was clear that sustaining community participation in PPI campaigns is becoming even more challenging within the context of increasing resentment and suspicion. Community participation was limited and challenging because of increasing conflict of interest between local level community priorities of socio-economic development of their areas of residence and government's exclusive focus on polio eradication goals.

The underserved and marginalized communities within UP were lacking access to basic healthcare and sanitation facilities and there was a continuous demand to address the socio-economic development needs of the communities. Apathy of government towards basic socio-economic development infrastructure and services together with increased priority given by government to a single pulse polio immunization added to the decrease in community participation and increase in social resistance towards polio vaccine over the years. The nature of social mobilization strategies was top down designed with limited focus on sharing the messages and information related to NIDs and benefits of OPV to mobilize masses towards the PPI program. The top-down program related information and directions given community for

specific actions required for achieving the goal of polio elimination in the country complete failed to take into account communities needs and priorities. Post outbreak stronger social mobilization innovative strategies with focus on addressing the socio-economic needs of underserved population in UP became indispensable to strengthen the participation of Muslim community.

Despite hopes to achieve the global target during the years of 2000-2002 the optimism to achieve polio eradication was low in the country. This became apparent with resurgence of polio cases in UP and its spread to other states resulting in subsequent outbreaks in other states. Failure of expectations to see the last case of polio in India by 2002 and UP outbreak caught global attention.

Globally the 2002 outbreak in UP was taken very seriously by GPEI stakeholders as it had major implications such as increased financial burden for smoothly conducting the program activities, increased risk of exportation of poliovirus infection in other polio free regions from India and impediments for success of global polio eradication program in other endemic regions. Considering the seriousness of the polio outbreak and its impact on motivation and trust of donors and other partners in general. India and state UP became a major priority for WHO for addressing the challenges to success of the global polio eradication program. The repeated failure to finish the job of elimination of poliovirus globally also was greatly increasing the financial burden. It became very crucial at this period to fill the increasing funding gap. The WHO- director general in 2003 strongly urged for more financial support from international community for carrying out planned program eradication activities in polio-infected countries.

The UP outbreak caused major setback globally as well as to the overall program progress achieved in the country since 1995. By end of 2002 India was among the three countries along with Nigeria, Pakistan contributing to 99 percent of polio globally. Endemic states in India alone were contributing a large share of polio cases to total global polio cases count.

Beginning of 2003 post outbreak it was evident to the national polio experts that while the endemic circulation of wild poliovirus was stopped in rest of India. It is sustained in UP and Bihar and these states have continued risk of importation of poliovirus to other polio free states and neighbouring countries.

India situation was regarded as *unique* in 2002 compared to other polio endemic countries because of large number of polio cases; since 2000 fewer number of NIDs/SNIDs conducted; and only polio endemic country where poliovirus transmission is extensive to polio free states and was capable to re-establish in few states.

Globally complexities and uniqueness of poliovirus transmission in India demanded urgent measures to stop the spread of poliovirus to polio free states within India and in other polio free regions. At the country level in India addressing in operational gaps and improving program performance to restore remarkable success achieved initially became a priority.

After the outbreak of 2002 UP became central priority for national polio experts for strengthening of polio implementation program. For approaching years, it became highly essential for India to take strong structural and operational changes to the PPI program within the endemic state of UP and other states with low polio immunity. Stopping polio virus transmission within UP and its neighboring states became core of policy guidelines issued in the year of 2003 and subsequent years.

The 2002 outbreak was alarming to government and polio experts in the country as it derailed the continuous program progress achieved so far. But it also highlighted some of the core problems in eliminating poliovirus in UP and in other endemic states which remained unnoticed by polio experts before. Apart from operational gaps and poor management and performance of program in UP. Polio eradication implementation was encountering problems of compliancy, provider fatigue, community fatigue and growing suspicion and anger of people towards repeated PPI campaign.

New set of strategies and innovations were drawn to address implementation challenges in UP specifically. Major structural changes to PPI program were taken to increase political ownership of program within UP and increase community participation particularly from high-risk Muslim community. Measures implemented in UP were replicated in other infected states to strengthen the pulse polio immunization program and improve the polio immunity gaps.

Frequency of NIDs/SNIDs was again increased from four to six per year in statewide with SNIDs focusing on reaching maximum children in each round in polio endemic states. In borders states of UP additional SIAs rounds were implemented to protected decrease the risk of spread of poliovirus outside of state. Large scaled mop up campaigns were implemented in polio-free states.

More emphasis was given to strengthen surveillance system in high-risk states and districts. Also, priority was given to use of surveillance data for informed decision-making in program planning and execution. Addressing the sub–optimal surveillance indicators, state surveillance reviews were initiated in 2002 to be regularly followed in large states to address gaps in surveillance system particularly in UP.

Lack of political engagement, adequate accountability and supervision to the overall health system in UP were prominent reasons for low quality of SIAs resulting in failure to reach children causing resurgence of polio cases.

After the outbreak it was considered essential to systematically increase engagement of political and government leaders from highest level to the district level to the PPI program. For this purpose, programmatic structural reforms were made to increase ownership and accountability of PPI program from highest level to the district level particularly in UP. It also strengthens political commitment and facilitate better co-ordination and communication between national government and state government related to PPI program activities.

Accountability of each government officials and responsibilities of conducting regular monitoring meetings were clearly defined from national to state and district level in UP. Major shift taken in UP was putting PPI program ownership in the state under the direct supervision of state Chief Ministers, appointment of additional commissioners in each of the seventeen divisions of UP and establishing immunization cell (department) in Lucknow under the direct supervision of secretary of health and family welfare for managing both routine immunization and pulse polio immunization program.

Sub- optimal quality of NIDs/SNIDs and failure to reach all targeted child in each and every round before 2002 were significant causes for persistence of poliovirus in endemic reservoirs and its resurgence in UP spreading to other states. Ensuring high quality of immunization activities in high-risk regions number of measures were taken in UP.

More flexibility was given to all states to decide on the booths and number of days required for house-to-house activity to ensure quality and adequate coverage. Increase in participation of female members as vaccinator or as a third team member in house-to-house

vaccination teams, appointment of block monitors to support micro planning and facilitate monitoring activities, more emphasis to collection and review of monitoring data during each SIAs round to identify areas with low SIA quality and in need of increased social mobilization efforts, increase in role of partners agencies in high-risk states particularly UP for supporting state government, management of PPI operations, providing technical and management support to all endemic districts, and monitoring and sharing of monitoring data to central and state government for improving quality of SIAs rounds.

With the aim effectively reducing the existing community fatigue and social resistance particularly among underserved minority marginalized communities in endemic areas of UP. One of the innovative strategies drawn and implemented in 2003 was 'underserved strategy' by UNICEF in coordination with Government of India in UP. This shift in social mobilization strategies was necessitated to address the various myths, misconceptions and change the attitude of people towards polio vaccination. Particularly to increase accountability of the program towards the needs of the underserved Muslim communities and increase their participation and ownership within the program.

Consistent with its name the main purpose of underserved strategy was to reach out to the families in the areas with poor access to basic services such as health and sanitation together with factors facilitating persistent of high wild poliovirus infection. High-risk districts and blocks were prioritized for implementation of this strategy to address the demand of increased access to basic services and facilitate interpersonal communication between vaccination teams and underserved communities making it less resistant based more on trust and clear understanding of program purpose. This new strategy was designed as an additional component of overall PPI communication program to increase engagement and ownership of minority and

marginalized socially excluded groups which also include scheduled caste Hindus and scheduled tribes and Muslim minority community of UP.

Specifically, to address the demand of basic health and socio-economic development needs of marginalized communities 'Add on interventions' were implemented under underserved strategy by CORE organization. Interventions were taken under this strategy address the concern of underserved populations providing sanitation and safer water facilities, promoting family and health care practices in the community to increase more acceptance of community of the PPI immunization.

In UP special efforts were taken by address the ongoing resentment, resistance, and mistrust among Muslim communities. Involvement of minority communities' leaders, pediatrics and medical societies association, and grassroot organization in planning and implementation of SIA activities was given more emphasis to address programmatic challenges pertaining to their community needs. Particular focus was given to increase leadership of Muslim leaders within district and block task forces.

Extensive social mobilization and IEC campaigns specifically targeting Muslim communities in UP to address the myths, rectify misconceptions, and suspicions around polio drops and increase their acceptance of the PPI program. With the help of Muslim religious leaders, famous personalities, institutions, universities, groups and local associations and certain individuals as community influencers efforts were made to develop more positive attitude of community towards PPI campaigns and bridge the community trust gap within the program.

The year of 2003 was seen as a milestone year as it changed the focus of program to high-risk areas and enforced many operational and structural measures to the strengthen the

performance of the program. These measures facilitated substantial progress in performance of polio eradication program in shortest possible timeline of over a year ever in the history of program implementation. After the outbreak of 2002 particularly the situation in large reservoirs of poliovirus UP and Bihar was highly encouraging. The situation in high-risk endemic state of UP and Bihar improved considerably during and by the end of 2003. Compared to 2002 during the year of 2003 was lowest transmission year recorded with lowest number polio cases and under-immunized children reported.

By end of 2003 major areas of improvement in UP compared to other states were improvements in performance of surveillance to accurately identify and define the high-risk areas within state and within districts, increase in high level political and government engagement and leadership facilitating stronger commitment at all levels towards PPI, high political commitment resulted in continuous and sustained improvement in quality of implementation of SIAs conducted and increases overall coverage specially SNIDs coverage increased reaching larger number of children compared to previous year, improvement in quality of SIAs resulted in decline in proportion of under- immunized children, and increase in immunization status of children particularly among Muslim children of Western UP and younger children.

Two of the significant aspects for increased in SIAs quality and coverage in UP were focus on socio-cultural diversity of the vaccination teams within districts with increased participation of female vaccinator and community members in the vaccination team and focused targeted communication and social mobilization activities resulting in increased community involvement in PPI cycles particularly in high-risk districts and blocks.

Overall reduction in the immunity gap nationally and in targeted states of northern India was reassuring for government and national polio experts that challenges encounter during SIAs in immunizing all children with OPV vaccines particularly in highest risk areas can be overcome with strong government support at all levels, effective communication and technical strategies.

But despite encouraging achievements and reassurance that the program strategies were effective. The overall improvements were not sufficient to end poliovirus transmission in endemic regions and achieve polio free status.

Problem of sustained funding for conducting timely planned program activities remained a major challenge for sustaining the effectiveness of innovative program strategies implemented in endemic states as well as in high-risk states. Shortage of funds and other resources remained consistent for complete implementation of underserved strategy and other communication activities.

Although the success achieved in highest risk state of UP was encouraging compared to other states in 2003. But variability in SIAs quality implementation and practice of missing large number of targeted children in every round continued in some districts.

Despite the incremental progress seen in the state of UP it remained major source of poliovirus transmission. Major areas of concern remained improvement in immunization status of Muslim minority and young children (<2 years). Significant variation improvement in immunization status still remained among Muslim children of UP. Lesser number of SIAs conducted, high birth rates and weakness in the implementation of routine immunization resulted in decline in immunization status of Muslim minority and young children during second half of the year 2003 in UP.

Overall significant variation observed in quality implementation of the program among and within all states remained a cause of concern for achieving program progress. After 2002 the entire focus of the government was not only to strengthen program in endemic states of UP. But also, in other states reporting extensive immunity gaps. By the end of 2003 although the overall quality of SIAs improved covering large proportion of targeted children. Existing immunity gaps outside UP remained in other high-risk areas a cause of concern to interrupt poliovirus transmission in the country.

Outside UP other high-risk states and polio free states became at increased risk of poliovirus. Compared to progress achieved in UP ten infected states outside UP identified with polio immunity gaps didn't progress satisfactorily. These were the states targeted with intensified SNIDs for strengthen of the program. The non-endemic polio free states where mop-ups were implemented also started showing significant immunity gaps particularly among young children. Resurgence of poliovirus transmission in few polio-free states became a major risk for progress achieved in endemic states and other polio free states. Lack of political ownership and high political engagement, non-compliance of recommended measures for improving program performance, lagging behind in quality improvement indictors of SIAs were some of the operational gaps in states outside of UP.

Owing to existing immunity gaps serious risk of resurgence of poliovirus transmission remained. Thua the focus of the program implementers remained on both endemic reservoir states of UP and Bihar as well as on other high-risk states and polio free states where quality in implementation needs to be achieved and sustained.

At the beginning month of 2004 the six ministers of health from endemic countries (Nigeria, Pakistan, Niger, Afghanistan, Egypt, India) were called for a meeting at WHO

headquarters in Geneva. After extensive discussion on challenges in implementation of GEPI strategies. The outcome of this meeting was signing of the Geneva Declaration for eradication of Poliomyelitis by all health ministers, a global commitment to end poliovirus transmission in their countries by 2004. Clarion call to stop polio forever was given by WHO specially addressing the endemic countries making them responsible to take rigorous actions with the vision that 2004 is the final year for interrupting poliovirus transmission globally.

Consistent with the commitment made at the Geneva Declaration, the ministry of health and family welfare the year of 2004 was seen at the target year to end poliovirus transmission. The program performance made by the end of 2003 was encouraging enough to call an end poliovirus.

Sustaining to the progress made so far three components were considered essential to stop poliovirus transmission in 2004 – achieving and maintaining stronger government leadership from highest to lowest levels, ending transmission in endemic reservoirs of UP particularly in western region and Bihar as well as in high-risk areas outside UP, and sustaining the national level population polio immunity to avoid emergence of other high-risk areas.

Accelerating the polio eradication efforts in the country first six months of 2004 were targeted for ending transmission with implementation of high quality SIAs and mop-ups campaigns in second half of 2004 to end the final chains of polio transmission.

Consistent with the global commitment aggressive and accelerated polio immunization activities were conducted. Subsequently measures were taken particularly focusing to build strong and sustained government leadership and direct oversight from prime minster level/Union health minster to state chief minister/chief secretary/ district commissioner/district magistrate level for all polio eradication activities, improve and maintained the overall

population level immunity nationwide through multiple SIAs multiple rounds (increase in number of NIDs to five rounds and intensified SNIDs targeting on high-risk states), focus on quality improvement through operational and communication strategies to reach each and every child in 2004, ensuring full participation of all minority groups and underserved populations aggressive communication strategies and enhancing surveillance sensitivity from national to village level.

In view of 2004 deadline, it was declared by national polio experts by the mid of year any poliovirus case detected in the country were treated as a public health emergency.

Despite the aggressive and accelerated efforts polio transmission by the end of 2004 was not interrupted in the country. Two areas of improvements achieved by end of 2004 were improvement in surveillance sensitivity particularly in endemic states of UP and Bihar and high level of polio immunity achieved in high-risk states and non-endemic states outside endemic reservoirs areas UP and Bihar.

Although the number of polio cases reported remained lowest compared to past years. But failure to interrupt the transmission in endemic reservoir areas of UP and Bihar further extended the deadline to eliminate polio in the country. By the end of 2004 it was necessitated for the program implementers to be vigilant on the two on the high intensity of poliovirus in largest polio reservoir areas of UP and Bihar. Particularly the program was focused in endemic areas of western UP which became the largest source of all polio cases originating in other states of India. In western UP largest cluster of type 1 was sustained by the end of 2004. Districts in western UP remained at higher risk of exporting poliovirus to other areas in UP, other states within India and globally.

The western UP along with central Bihar became a major risk and threat to the overall global success of the eradication program in 2004 and in subsequent years.

The program was extended to 2005 with focus given to high priority districts in western UP, Bihar and Maharashtra. By this time extension of deadline and the failure to reach all the targeted children was adding to programmatic and financial implications every year and making the global polio experts more concern on challenging status of polio eradication program in endemic high-risk states of India. As the poliovirus reservoir were limited geographically to certain areas in endemic state of UP and Bihar risk of exportation of infection across India and to other countries remained. Extension of deadline means that national polio immunity needs to be sustained again through rigorous high quality SIAs to prevent resurgence of poliovirus in polio free areas. Failure to reach all children in the stipulated time period negatively was impacting the motivation and enthusiasm of both program providers and community. Above all extension of deadline was adding on to the existing burden on program budget where already the program was struggling every year to manage funds and resources from different sources to implement to carry out polio immunization activities on time.

At the global level extension of deadlines along with repetition of the rounds every time and failure to reach all children was taken negatively. The major problem with polio program in India considered was that with every polio round repetition it added to already high cost of the program, required again timely vaccine procurement, result in wastage of vaccines with resurgence of polio cases and outbreaks. This cyclic process of repetition of rounds and increase in polio cases despite enormous resources and efforts put into the conduct of program was adding to higher polio infection risk for children.

High overall program cost, depleting enthusiasm of program providers and community, and consistent efforts to improve deteriorating quality of SIAs conducted not just in endemic regions but also in non-endemic states were some of the major problems program was encountering by this phase of PPI.

Every time repeated, accelerated, and aggressive efforts made towards achieving interruption of poliovirus in the country increased the program budget considerably. Increase in number of SIAs additional rounds of high quality for final push towards elimination of poliovirus, irregularities in funding were often observed for carrying out the PPI program activities added to the already existing program of funding shortage.

The discrepancies in funding between government of India and its national and international partners was consistent with overall global fund shortage within GPEI for implementing program in remaining endemic states. It had implications on timely fund flow for the program activities, vaccine procurement price increasing the overall cost of the program and risks of polio infection. Government of India often had to make commitment at several times to address the shortage of funds to timely implement program activities. In cases where government was not able to timely release funds partner organizations such as UNICEF provided a bridge loan to compensate the shortage of funds. Such funds sanctioned were done only on exception cases generally for procurement of OPV doses.

The repetition of SIAs rounds, continuous failure to reach children, and high pressure to achieve high-level immunization status of children and repeated failure to achieve desired success in interrupting poliovirus in stipulated time period was adding to the increasing providers implementation level fatigue. On the other hand, repetition of SIAs rounds, lack of clear understanding on repeated doses of OPV, consistent call by the government to immunize

children added to community fatigue. Continuous deterioration both in morale and confidence of workers and community became a significant concern and cause of major risk for spread of polio infection for polio experts. Every year consistent efforts to sustaining motivation of both community and workers towards the polio program were given more emphasis with focus on including more enhanced and comprehensive communication strategies particularly in high priority reservoirs areas.

Another major concern was deteriorating overall quality of SIAs particularly after 2000 not only in long standing endemic reservoir of UP and Bihar. But also, in other high-risk states outside UP and non-endemic states polio free states with new resurgence of polio cases in earlier polio free areas. Some improvements immunization statuses of children were observed after 2002 polio outbreak in UP and other states outside UP in 2003 and continued in 2004. But achieving the optimally high quality of SIAs necessary for interrupting of poliovirus in all areas remained a technical challenge in the country despite more rigorous planning and monitoring of SIAs every year.

The accelerated polio efforts put in 2003 were systemically increased in 2004 and 2005. Despite the failure to achieve the Geneva commitment of ending polio virus transmission the performance of the program in the year 2004 was taken as extraordinary progress made for achieving polio eradication by government and national level polio experts committee. Building on the increased performance achieved every year from 2003 by end of 2004 the poliovirus transmission geographically and genetically was restricted to endemic reservoir areas of UP and Bihar. By the end of the 2004 the program performance was hugely increased and the country was seen on the verge of stopping the poliovirus transmission. The program performance achieved in 2004 continued in 2005. The historically significant progress in

performance achieved since the start of the program in 1995 until now built hopes and confidence to stop poliovirus in the country by the end of 2005.

It was considered by polio experts as great opportunity in the history of program to stop poliovirus as all the polio cases reported in the country were caused by exportation of poliovirus from limited to endemic reservoirs of UP and Bihar. Most of the states were reporting polio-free status by the end of 2005. But the transmission of poliovirus was not stopped and continued in the endemic reservoirs of the country – states of UP and Bihar. With continuous of poliovirus transmission in endemic countries the global deadline to interrupt the poliovirus transmission was shifted to 2007 from 2005.

Compared to rest of India poliovirus transmission in endemic states of UP and Bihar was not stopped by the end of 2005. The hopes and determination of government to achieve the goal of poliovirus interruption in first few months of 2005 failed due to continuation of poliovirus in high priority districts of western UP, Bihar and greater Mumbai/Thane. Along with other areas at risk for continuing transmission of virus were central and eastern UP and West Bengal. The focus of the program and its limited resources was diverted all to high priority districts to stop the transmission through stringent efforts and high quality SIAs. Maintaining high level immunity and responding to any wild poliovirus as a public health emergency through rapid and high-quality mop-ups were strategies adopted for rest of the country.

Particularly overcoming these continuous high priority risk reservoir areas of UP and Bihar was challenging. From 2003 to 2005 some of the significant programmatic problems in these areas, and other high-risk states were - consistent gaps in implementing high quality SIAs, continued missing of houses in endemic districts of western UP, lack of sustained national and state government leadership, lack of high-level oversight and strong ownership at all levels,

weakness in supervision, gaps in training of vaccinators, and in implementation of coordinated monitoring activities.

One of the major problems to that during the SIAs round the polio program was consistently missing large number of transient children migrated to other states in UP and Bihar. Children of transient families remained unvaccinated or under vaccinated as they missed the OPV doses both in routine immunization and SIAs. It was much later within the program the problem of large number of migration of people every year, mostly seasonal was recognized as a potential risk factor for spreading polio infection from endemic regions of UP and Bihar to other states in the country.

By the end of 2004 along with transient population, urban slums populations, and nomadic populations was seen as risk for continued polio transmission in the country. Thus, the focused was increased on reaching children of such population to ensure complete coverage during routine immunization and SIAs rounds particularly in UP and Bihar.

Consistent with the problem of migration as a serious problem ensuring complete coverage of all targeted children. Transit vaccination strategy was launched in 2005 with the purpose to catch the migration streams. Along with tracking the transient areas and eligible children in each district as a major strategy. Efforts were made in each SIAs round by mobile immunization teams to provide polio drops at areas of transit point and assemblage points such as at railway stations, bus stands, highways, markets, and at religious and community festivals. In subsequent PPI cycles transit vaccination strategy became a major component of the program implementation to ensure maximum coverage of transient children particularly in UP and Bihar.

Two of the significant achievements by the first half of 2005 were high quality of AFP surveillance data and high-level increase in immunization status of children.

Previously the problem of missing poliovirus transmission was a major risk factor for persistence poliovirus in the country particularly in endemic areas of UP and Bihar. High sensitivity of surveillance was focused more against specificity of detecting AFP cases to eliminate the risk of missing poliovirus transmission. High quality improvement in surveillance performance and uniformity of basic quality surveillance indicators across districts made the surveillance data more reliable by early 2005 for making programmatic decisions. The laboratory network in India at this period was already performing at high quality level within timelines in the past despite the continuous increase in workload.

Improvement in access to children with OPV and consequently increase in immunization status was a result of continuous efforts put in past years on expansion and rigorous implementation of social mobilization and communication activities particularly to reach underserved Muslim populations in Western UP.

Within the implementation of the program continuous strives were made to search and implement innovative additional strategies, both operational and communications which could improve access to children at significant level particularly in challenging high priority districts in underserved communities of western UP. Particularly focus was given to strong operational activities and technical inputs especially in underserved population. Continuous focused efforts were made to reach each and every child in high-risk districts of UP and Bihar. Apart from improving program indicators expansion and implementation of transit strategy resulted in accessing more moving population in three endemic states. Similarly with underserved strategy program was able to access more children of underserved population particularly Muslim

population in high-risk districts of western UP. Increase in number of teams having Muslim vaccinator and local influencer greatly enhance community acceptance of the program. Although during the first half of 2005 improvements were seen in government ownership both at national, state and district level in endemic states contributing to increase in performance of the program. But these improvements were not sustainable towards the end of 2005.

Thus, increase in high performance AFP surveillance along with high level performance of laboratory network, high coverage and high-level increase in immunization status in the country specifically in high priority districts were encouraging indicators for stopping the poliovirus transmission in the country by the end of 2005.

5 Vaccine Immune Response Failure

By the end of 2005 transmission of poliovirus in high seasons declined consistently to extremely low level in the country and was restricted to western UP and Bihar. Historically this achievement was remarkable compared to pervious of high transmission periods. Epidemiologically there were positive evidences for interruption of circulating poliovirus in 2006. Encouraging and confident with this progress program implementers hoped that poliovirus from the country will be knock out in the year of 2006.

With the objective to maintain the momentum of the program performance in the country gained by the end of 2005. Major emphasis in 2006 was given to maximizing on the progress already gained and to increase the program effectiveness in low transmission seasons to reduce the strengthen of the poliovirus in peak transmission season in high-risk districts of UP and Bihar.

But despite improvement and progress in program performance in western UP. Impact of these efforts failed to closed the immunity gap still prevalent in western UP. the consequence of this

was resurgence of polio cases during first half of 2006 in western UP. Although the intensity of the outbreak in terms of number of polio cases reported was less compared to previous years due to increase in overall high immunity against poliovirus by end of 2005. But majority of cases above 80 percent of polio cases were reported from UP and rest from Bihar and fourteen other states and union territories in India. An outbreak by the middle of the year with continuous increase in number of polio cases in high-risk districts of western UP significantly impacted the progress made so far.

In the previous year's consistent efforts were made strengthen to improve the PPI campaigns implementation in the country. This reduced the total numbers of polio cases were significantly in the country along with increase in overall polio immunity by the end of 2005. But despite this overall high performance of the program outbreak in western UP not only disrupted the program performance. But also uncovered existing operational, environmental and sociological lacunae in the implementation of the polio eradication strategies in the country.

Geographical and genetically the spread of the circulating polio virus was limited to few districts in western UP and Bihar. Endemic reservoir areas in western UP and Bihar were causing all the viral spread to other states and increase in polio cases in India. But in Bihar the spread of outbreak in 2006 was much less intense with limited increase in polio cases than in UP.

The consecutive outbreaks in UP since the program started in 1995 in within the context of declining trend in number of polio cases great hindrance for achieving overall success in stopping poliovirus in the country. The pattern of occurrence of outbreak and spread of poliovirus was similar, reoccurring every four years centred in historical endemic reservoir

areas in India. The endemicity of poliovirus in districts of UP particularly western UP was frustrating not only for polio implementers in the country but globally also. By mid of 2006 observing the situation of western UP the national level polio experts committee acknowledged that it is more difficult to stop poliovirus in western UP compared to other areas in the world.

Globally the endemicity of clusters in northern India was causing an overall concern for achieving success in eradicating polio in one of the largest densely populated country. The persistent presence of poliovirus and slow progress of overall PPI in India was frustrating and worrying. As despite consistent commitment and stringent efforts India was failing to make the polio program succeed. The efforts made to make the program effective in stopping poliovirus every time was wastage with new polio cases and repetitive outbreaks. This was overall adding to the high cost of the program and considerable wastage of investment and medical resources used for the program. Repetition of activities of the program was increasing the cost of the program and wastage of large amount of investment globally.

Scaling up of activities and consistent efforts were repeatedly made just to make the program effectively work in UP and Bihar as overall success of the polio program in the country was depend on these states. Despite tremendous efforts poliovirus transmission was not once stopped in these two states since start of the program. This was resulting in repetition of activities of program implemented with more intensity every year reach each and every child with polio vaccine again and again. It was not only adding to the overall cost of vaccine procurement, social mobilization activities and other activities. But was also frustrating for community whose children were given more than recommended three doses of polio given to children of other countries. But it was encouraging for the polio program progress in the country that the geographical spread of poliovirus was limited to only few districts in western UP and Bihar in 2005.

Since start of the program, it became evident that improvement in performance of the polio program in UP were not uniform. The average improvement of polio program performance in UP was masking some of the highly endemic districts of UP where deteriorating quality of the program was persistent. Despite overall improvement in quality and decreasing areas of poliovirus circulation some high-risk districts in western UP were continuing the circulation of poliovirus. Majority of polio cases in 2006 were reported from these high-risk districts in western UP. Western UP was again central to occurrence of polio outbreak of 2006 as previously seen in history of polio program in India. Its endemic reservoirs areas districts of Moradabad and JP Nagar in western UP were responsible for spreading of poliovirus within state, covering much of the area of western UP, spreading to central and eastern UP and spreading to neighbouring states. The outbreak also occurred in endemic districts in north-central of Bihar and spread outwards to other neighbouring regions. But in Bihar the spread of outbreak in 2006 was much less intense with limited increase in polio cases than in UP.

Western UP remained central to polio outbreak in India. Few districts in western UP emerged as consistent endemic reservoir of poliovirus. Apart from highly prevalent type 1 cases poliovirus cases since 2005 the number of type 3 poliovirus cases increased and all were centred in 2006 in few districts in western UP. Within the western UP it was Moradabad district and its sub-regions clusters were consistent risk for poliovirus exportation in repeated manner to other parts of India and to other countries. These endemic pockets of districts since 1998 were reporting very high number of polio cases and were consider risk factors for overall success of the program. In 2006 consistent with previously history of reporting high number of cases, there was significant resurgence of polio cases in these endemic clusters of districts. Both type 1 and type 3 polio cases were reported from Moradabad district in 2006 with all type

3 reported cases in the country were from this district. It was the only district where both types of polioviruses were highly prevalent in the country.

Efforts put into the program in western UP were failing consistently leading not only increase in overall cost of the program. But also increase in global pressure on the government along with program implementers. There were many operational programmatic gaps and socio-cultural and economic and political factors inhibiting the program effective implementation leading to stop the final chains of poliovirus transmission in these endemic clusters of districts in western UP.

There were various operational programmatic lacunae in implementation of program contributing to deterioration of quality of SIAs in endemic few clusters of districts in western UP. In few clusters of UP the program implementation of PPI consistently suffered in the past several years from both operational problem and socio-religious problems. Serious gaps in program implementation, failure to reach difficult to reach population, weakness in social mobilization campaigns, consistent difficulty to mobilize populations to accept the program due to existing rumours and false propaganda about the PPI program among the community were some of the prominent factors contributing to difficulty in stopping poliovirus in the western UP.

The 2006 outbreak was caused due to failure to reach all targeted children in each and every SIA round in late 2005 and early 2006. Uneven and deteriorating quality of SIAs implemented and missing of houses consistently in every SIAs rounds created a large pool of un-immunized and/or inadequately immunized children continuously sustaining the circulation of poliovirus resulting in resurgence in Western UP. Maintaining huge gaps in polio immunization in high priority areas gaps and missing of large number susceptible children from

OPV immunization was caused because of existing gaps in monitoring system of SIAs, inconsistent and infrequent state government engagement and direct oversight on the quality of program implementation, vacant health personnel's positions and gaps in availability of adequate human resources at district and block level for maintaining needed supervision of the program, low performance and inappropriate vaccine administration practices by vaccinators and persistent vaccine avoidance behaviour among community.

Such large number of susceptible children were missed were majorly because there were serious gaps in technical capacity of vaccination teams to effectively administer the polio doses. Vaccination teams were lacking inter personal communication (IPC) skills to effectively interact with families about importance of OPV doses facilitating acceptance of vaccine in households. Apart from this vaccination teams were significantly lacking appropriate vaccine administration skills and were using incorrect techniques such as vaccine administered to sleeping child, vaccine dose spill-out by children and false identification of eligible children false identification of eligible children. The inadequate capacity of vaccination teams to perform their jobs effectively was contributing to wastage of polio vaccine doses. Vaccination teams was also lacking inter personal communication (IPC) skills to effectively interact with families about importance of OPV doses facilitating acceptance of vaccine in households.

Concurrently with communication strategies and social mobilization campaigns vaccine avoidance practices were followed by community. These practices remained identified and were noticeable after 2006 evaluation of program to identify causes of outbreak. The continuous pressure by the government on reluctant families to change the behaviour of such families towards OPV vaccination and provide polio vaccine to their children made them to adapt practices which avoid vaccine such as false marking of fingers without administering OPV doses. These vaccine avoidance practices were followed on requests of parents followed

with support of vaccinators team while administering OPV doses. Serious lacunae in traditional SIAs monitoring system failed to capture these covert vaccine avoidance practices by parents.

Failure to reach difficult to reach population of Muslim community resulted in decrease in coverage of Muslim children and increase in percentage of missed houses. This caused in increase in number of susceptible children over a period of time resulting in outbreak.

Immunization status of Muslim children was still lower compared to other general population in 2006 outbreak. Majority of increase in number of polio cases were reported from children less than 3 years and from unserved Muslim community of UP. This was in consistent with low polio immunity and disproportionately high number of polio cases observed among Muslim community of UP during 2002 outbreak.

After the 2002 outbreak enormous efforts were made within the program implementation to engage underserved communities of UP. Consistent expansion of innovative communication and social mobilization campaigns were made to ensure that children of minority underserved community are not missed from the polio immunization. Despite this in 2006 disproportionately higher incidence of polio cases were reported from minority population. There were consistent gaps in enhanced social mobilization campaigns implemented in few clusters of western UP.

Many covert reasons developed resulted in deterioration in quality of social mobilization campaigns and every SIAs rounds failing to immunize children of minority communities. Vaccine resistant behaviour and vaccine avoidance behaviour remained dominant factor for consistently missing large number of susceptible children among minority population and continuing the risk of circulation of poliovirus in few districts of western UP.

During the beginning phase of the program implementation, it became evidently distinct that reluctance of certain households and social resistance among minority communities was a consistent problem among minority communities in few districts of western UP. Rumours, resentment and suspicion created an environment full of mistrust towards OPV doses given to children of minority communities.

It was identified during early phases of program that resistance and suspecting behaviours among households and community developed because of negative rumours about the OPV, concerns on safety and efficacy of OPV drops, suspicion and doubts among people about the motive of the program; negative media coverage, lack of support from Muslim religious leaders such as Imams and Moulvis and lack of awareness on the rationale of repeatedly giving of polio drops to their children.

Adverse events following polio vaccination among few cases such as sickness, polio paralysis and/or death of children caused overall bad experience among people. Rumours about OPV negatively influenced community behaviours and non-acceptance of polio vaccine were - vaccine causing infertility/impotency especially among Muslim boys, used as a tool for population control, vaccine is made from pig's fat/meat which is forbidden in Islam polio immunization part of international conspiracy by Jews and US to finish the community so a different vaccine is given to Muslim children, suspicion on oral methods of giving vaccine against the general intravenous method, and why focus on only children and not adults. Also, some households felt no need to give polio drops to their children owing to believe among adults that they are healthy and survived without vaccination. Both media and religious leaders were not very supportive and circulating distorted facts about pulse polio immunization program adding to existing doubts and suspicion among communities. At some places use of coercion methods to compel reluctant households for giving OPV drops to their children

resulted in total or partial resistance towards PPI campaigns. These were some of the socio-cultural barriers which made people reluctant towards the polio eradication program.

Rumours and vaccine resistance behaviours within the course of program implementation became one of the prominent hindrances in reaching out to all children ensuring complete coverage. This demand from time-to-time separate individual surveys and research studies to understand the nature of rumours related to PPI and how and why they are spread in particular among minority communities in few districts of western UP. Although the sources spreading them remained unclear. But rumours related to OPV were circulated just before polio immunization campaigns, nature and content of rumours changes with time and areas, spread through both IEC materials and interpersonal communication by religious leaders and associations and were not sustainable for long period and thus not able to cause long lasting resistance to SIAs.

Apart from operational and contextual socio-cultural factors, social determinants of health were significantly deteriorating the quality of polio program in few endemic clusters of districts in western UP. Social determinants and other environmental factors driving the high endemicity of few districts in western UP were distinctly identified and explicitly acknowledge the national policy experts only after 2006 outbreak.

Rumours and suspicion towards OPV were not only shaped by religious or socio-cultural reasons. But also caused growing resentment against government and prevalent perception among Muslim communities of being neglected from socio-economic development. Research studies studying nature of social resistance conducted explicitly stated that persistent social resistance among Muslim population not seeking polio vaccine is a problem of not adequately giving attention to social determinants of health as an end game polio strategy.

Vaccine related rumours and social resistance to (OPV) was largely reported from socially economically marginalized community in western districts of UP largely deprived of basic amenities, health infrastructure and services. Resentment, misconceptions and suspicion developed among community within the context of government exclusive focus towards polio vaccination neglecting other prevent childhood disease and other diseases, insufficient primary health care services, and dismal living conditions. Dearth of socio economic and health services added to fear and suspicion of OPV and fatigue caused repeated rounds of polio immunization. Further government exclusive focus towards polio vaccination by resulting in large number of cases among Muslim boys under two years of age.

The context specific social determinants of health also explained the differences in endemicity of between few clusters of western UP compared to eastern and south-central parts of the state. Zero-polio case status was achieved several years ago by eastern and south-central parts of UP and were reporting smaller number of polio cases over years. On the other side continued circulation of poliovirus in the endemic areas and reporting of higher number of polio cases repeatedly from few endemic clusters of western UP became central problem in stopping the poliovirus in the state. The overall performance of SIAs rounds and progress in interrupting poliovirus was better in south-eastern clusters of districts then in endemic districts of western UP. High endemicity of few districts in western UP was also caused by high population density, rapid urbanization, high proportion of minority Muslim population, low routine immunization coverage.

In endemic districts of western UP Muslim population was residing in higher proportion in urban areas compared to eastern and south-central parts. High population density together with high birth rate and very high number of young children population were adding to operational difficulties within the program to achieve complete coverage of all children. Every

year the size of targeted children population was increasing due to high birth rate making it difficult for the program to ensure high proportion of vaccinated children and reducing the immunity gaps. Sustaining polio virus transmission was enabled because of high population density which aiding child to child poliovirus transmission rapidly in the areas and very poor sanitary conditions.

Sub-optimal quality of SIAs, missing of large number of children, resistance, resentment, mistrust among minority community, fatigue and compliancy both among community and providers, lack of government engagement and direct oversight required for sustaining the high quality of program and consistent difficulty to mobilize populations to accept the program due to existing rumours and false propaganda were consistent problems in few clusters of districts in western UP facilitating consistent immunity gaps observed and circulation of virus in the these areas.

Closing the existing immunity gaps was critical for stopping the poliovirus transmission in the endemic districts of western UP since the earlier phases of program implementation in high-risk areas. For the success in stopping transmission in western UP it was critical for the program to reach to around 95 percent of eligible children and ensure that children have properly administered polio vaccines completely vaccinated against the poliovirus in every SIAs rounds conducted in high-risk districts.

Achieving the desired level of polio immunity in the population was not only dependent on quality of SIAs rounds and ensuring that children completely vaccinated. But also ensuring high coverage of very young children through routine immunization (RI) in high-risk districts. National immunization programmes through its routine immunization services were one of the essential parts of four-pronged strategy promoted by GPEI for achieving the global goal of

polio eradication. It was essential that all the infants and young children are covered with polio vaccination both in annual SIAs rounds and through RI services. It was evidently learned from success of other industrialized countries that robust routine immunization systems and services were critical to achieving high coverage and reaching the regional goal of polio elimination. National immunization programme in well performing countries also had to also face difficulties in reaching pockets of hard-to reach population or unreached populations. Putting distinctive efforts to strengthen routine immunization systems and services was given major emphasis to prevent outbreaks, ensure high national vaccination coverage and ultimately to achieve the regional and global target of eliminating poliovirus.

In India RI services didn't get the considerable attention for required for stopping the poliovirus transmission in the country. Major operational issues on adequate logistical supplies, cold chain maintenance and reporting of stock outs of RI vaccines in some states were persistent in high burden areas. Missing of large number of children, under-immunization, low coverage, lack of RI services in urban areas, unreachable and hard to reach population groups and areas of Muslim and illiterate population remained consistent problem particularly in the states of UP & Bihar. Performance of overall RI to achieve child immunization goals remained far behind the stipulated targets particularly.

As majority of young children were consistently missed from RI every year creating the necessary polio immunity gap for continued circulation of poliovirus particularly in high priority districts of UP and Bihar. Intensifying routine immunization coverage in states of high burden areas was recommended by national polio experts committee. But planning and implementation of SIAs within the polio program remained a separate activity of focus from RI.

Deteriorating routine immunization coverages and low immunity among young children was given major emphasis improving RI only after 2002 UP outbreak. Strengthening routine immunization system was given more consideration through recommendation of separate strategies to states for maintaining high coverage. Regular reviewing on the implementation and progress of routine immunization plans and recommendation on strategies to strengthen RI services in all polio endemic regions was added as an essential separate agenda item for discussion in IEAG subsequent meetings. Strengthening routine immunization became a main focal area of polio interventions in high-risk areas particularly urban areas. Numeric data on service provided as part of routine immunization and progress reports providing information on specific timelines and milestones achieved for improving routine immunization was sought from polio endemic states. Major emphasis was given to the state of UP to strengthen the routine immunization after 2002 outbreak. States governments of both UP and Bihar were asked by national polio experts' group to prepare and implement a joint operational plan of action for both polio eradication and strengthening of routine immunization.

But the specific attention given to national immunization program in the country by national polio experts for improving the polio immunization coverage was not sufficient to strengthen RI and stop poliovirus transmission in high endemic states. There were several gaps in the overall routine immunization structure and it required adequate investment and distinctive efforts. Despite steadily strengthening RI services and increasing the vaccine coverage in the country large number of children didn't not receive all the recommended doses vaccine preventable diseases to ensure full immunization coverage. This impacted the progress of PPI since the early phases of program implementation in the country resulting in resurgence of polio cases in high priority districts. After 2006 polio outbreak in became evident in few

endemic districts of western UP one of the major difficulties to stop poliovirus transmission was low polio immunity among young children.

Less number of polio cases were reported from older children above three years of age who were mostly immunized compared to young children. Particularly poliovirus was largely infecting young children less than two years of age above.

Despite high coverage of polio vaccine through SIAs rounds per dose efficacy of OPV among very young children of less than three years of age was deficient to provide adequate polio immunity against the poliovirus. Further the RI coverage was very low in endemic districts of western UP adding to the difficultly of young children particularly those under two years to get enough polio doses to develop immunity against poliovirus. Thus, it was low immunization status of young children which continued the survival of poliovirus in endemic districts of western UP.

6. Change in Polio Vaccine -Concerns & Debates

It was imperative for the polio eradication initiative in the country to not only reach eligible children and immunize them. But to ensure that OPV vaccination immune response is developed in targeted children. Lack of required immune response in children was a major risk factor exposing the susceptible children to poliovirus infection thereby continuing the transmission.

Despite major efforts put forth in endemic areas of UP to improve the overall performance of the program sub-optimal quality of implementation and major operational gaps particularly in western UP remained requiring further sustainable measures for achieving the desired result of eliminating the poliovirus. The continuous programmatic challenges and problems in achieving high coverage with increasing immunity gaps raised questions on polio

eradication strategies used in the country by media, public health experts, health activities, academicians and scientists at several times. Particularly continuous failure of strategies to increase program performance in few endemic districts of western UP gained significant attention. Apart from community resistant behaviour and challenges in western UP to reach and immunize children. Low immune response started gaining much attention after 2005 raising many questions on overall polio program and quality of trivalent OPV vaccine used. Low potency of trivalent OPV was critical problem for the success of the program as it causes high incidence of polio cases primarily in vaccinated children.

Efficacy of trivalent OPV was extensively studied in eminent scientists in India much before the global commitment of GPEI in 1988 and launch of pulse polio immunization in 1995 in India. The problem of low potency of trivalent OPV was widely discussed by scientists in India as well as in international conferences on poliomyelitis. By 1960s trivalent OPV vaccine failure was identified where vaccine was not producing 100 percent polio antibody even after three doses. Clinical vaccine failure of trivalent OPV producing low antibody was majorly observed for type 3 and type 1 poliovirus resulting in polio infection and paralysis cases. The immune response of OPV was different in tropical region of India contrary to observed in other industrialized countries.

These research findings on low efficacy of OPV in Indian context were completely overlooked at the time policy formulation of both GPEI and pulse polio immunization program in India. Consistent with the WHO recommendation for all endemic countries trivalent OPV was chosen as a vaccine of choice for eliminating the poliovirus in India by policy makers. During the initial period of polio program implementation concerns were raised by public health professional and health activists on low efficacy of trivalent oral polio vaccine and its effectiveness in completely eliminating poliovirus in the country. After missing of 2000 global

deadline to interrupt poliovirus in India and 2002 outbreak in UP particularly concerns were raised on both effectiveness eradication strategies and efficacy of OPV in highly poliovirus endemic states of UP and Bihar.

But such evidential concerns on efficacy of trivalent OPV was refuted by government and not taken into account for making any significant policy change. Only after 2002 outbreak major measures were taken to ensure optimal quality of OPV within the program. Only pre-qualified OPV which guaranteed potency of vaccine was purchased for use in both RI and SIAs.

Questions overall efficacy of OPV in tropical regions were not only raised in India. But also, by international distinguished polio experts and scientists even before launch of GPEI. Findings on low potency of trivalent OPV in tropical and developing countries was widely discussed and disseminated at international forums by scientists.

Within the context of low potency of OPV to developed immunity against the polio infection, the polio program in the country continued to face to problem of low immunity in targeted children in endemic districts. Measures of government continued to focus on improving the operational gaps in implementation of SIAs, increasing the annual SIAs rounds and reducing the growing resistance of communities in endemic areas. Despite the seriousness of the problem, it failed the continued discussion on efficacy of OPV outside of government forums failed to draw attention of government for a longer period.

It was only in 2004 and 2005 that major evidence on low efficacy of OPV was published and ethical and policy contentions were raised strongly by interest groups outside of government. Evidence on large number of reported polio infection cases among highly vaccinated children became central to growing concerns and questioning of polio program

strategies in the country. By 2004 annually the number of SIAs rounds conducted in endemic regions of UP and Bihar reached 10-fold and children were given more than recommended three doses of OPV annually. Despite these efforts many polio cases were reported from children vaccinated with OPV more than four doses of OPV. The continued reporting of high incidence of polio cases in two endemic states called for attention that the trivalent polio vaccine is failing to provide optimal immunity for protection against the poliovirus. Concern on risk of failure of OPV vaccine as core strategy of polio program was strongly pointed by scientists.

It was evidently clear for government and national polio expert that there is continued occurrence of polio cases in large proportion among highly vaccinated children. The repeated occurrence of outbreak in endemic districts of two northern states along with continued high prevalence of type 1 and type 3 poliovirus, and increasing immunity gaps resulted in pilot study conducted by government of India on low potency of trivalent OPV and use of monovalent OPV in endemic states of India.

The serious epidemiological, environmental, and genetic limitations of trivalent OPV in the endemic regions of India as pointed out widely by interest groups outside of government were confirmed by the findings of the government commission research. The research findings also confirmed that contrary to high efficacy of OPV as used in developed countries resulting in elimination of poliovirus. In India there are multiple factors which limit its efficacy in different epidemiological and environmental conditions resulting in overall the poor efficacy in endemic regions.

The piloted research also stated that one of the prime reasons for low potency of polio vaccine in India is high prevalence of diarrhoea and presence of other enteric infections.

Presence of both poor sanitary conditions and high incidence of non-polio enterovirus (NPEV) in endemic districts of western UP were not allowing high OPV effectiveness building required immunity against poliovirus in children.

The research study confirmed that use of monovalent OPV (mOPV) type 1 and type 3 polio vaccine in endemic regions of India is highly efficacious particularly in areas with high prevalence of diarrhoea and other infections.

The government of India in 2005 introduced a major change in polio vaccination policy to stop the continuous of transmission of poliovirus in endemic districts of western UP. Consistent with the findings the new (mOPV) type 1 and (mOPV) type 3 was found to highly effective than trivalent OPV in endemic regions of western UP, the new polio vaccine was licensed for use in high-risk endemic areas of UP, Bihar and Mumbai/Thane/Raigad. Particularly the exclusive and extensive use of mOPV type 1 in SIAs started from 2005 in high-risk areas with persistent high transmission of type 1 poliovirus.

Change in polio vaccine at much later period in course of polio program implementation was an advanced innovative step of end game eradication strategy to completely stop continuous transmission of poliovirus in endemic districts. This change was in consistent with global advisory committee on polio to overcome the existing challenges of endemic areas in the world and increase the effectiveness of SIAs rounds.

But progress of the polio program was still slow in in endemic districts of UP and Bihar. Addition of mOPV was still slow to decline high incidence of polio cases reported. Despite introducing in UP the monovalent vaccine low population immunity became one of the major reasons for resurgence of polio outbreak in 2006. Major efforts done with change in polio

vaccine to enhance impact of SIAs failed to produce the high immune response to OPV doses in children in high-risk areas.

After the 2006 outbreak, it became evidently noticeable to the national polio experts committee that despite high coverage OPV vaccine doses were not sufficiently building the required immunity to prevent poliovirus infection among very young children of endemic districts of western UP. It was apparent that it is difficult to build high levels of polio immunity among children of high-risk areas of western UP. The low per dose efficacy of OPV in northern parts of India particularly western UP was low compared to rest of India. The low per dose efficacy of OPV among young children particularly among very young children of less than two year of age was a result of not only low RI coverage. But it was also widely pointed out by interests' groups that it was a failure of the trivalent OPV to develop adequate immune response among young children.

The 2006 outbreak clearly showed that consistent failure of polio program strategies in high-risk areas of UP was not only an operational problem to be resolved with strengthening of immunization campaigns and reducing resistance of families and community. But much of the failure of the program to reduce existing immunity gap in these areas is low immune response where lower efficacy of OPV among children was failing build adequate polio immunity against poliovirus in critically high-risk areas of western UP.

After 2006 outbreak difficulty in building adequate immunity response among susceptible children of high-risk areas was an overall risk and major concern to the overall polio eradication efforts in India. At this stage it became important for the program to close the immunity gaps not only with high quality of SIA rounds to reach the all-eligible children in

high priority areas. But also, with change of trivalent polio vaccine as demanded for long time by outside government interests' groups.

But there was no doubt among national level polio experts and government of India on efficacy of mOPV. Low routine immunization coverage of tOPV and children not adequately received mOPV1 introduced in 2005 during the PPI campaigns in span of just one year were cited as reasons for low population immunity resulting in outbreak in western UP.

Both international and national polio policy experts remained consistent with use of OPV and refuted any claims on low quality of vaccine and/or failure of strategies in endemic districts of India. There was a strong conviction that OPV has higher efficacy to interrupt the transmission of polio against and complete the goal of eradication.

Addressing the problem of deteriorating immune response in high-risk areas was critical for the success of the program. But globally as well as in India high prevalence of diarrhoeal diseases among children of India was viewed as one of the social determinants associated challenge as it does not allow vaccine to stay in the guts of children giving lesser opportunity to children to develop immunity resulting in poor immune response of vaccine. High incidence of other enterovirus or bacterial infections causing higher incidence of diarrhea remained primarily reasons for lower vaccine effectiveness of OPV.

It was also distinctly apparent that in high-risk areas clusters of western UP developing immune response was difficult despite multiple doses of OPV given to children in span of one year. Repetitive polio doses in every SIAs round (more than four doses) were justified by polio policy stakeholders as critical to maintain the desired immunity among children in endemic regions to counter the failure of polio vaccine in India. Further immunization of most of the children under five years of age and continuous transmission of poliovirus in high-risk areas

with lower vaccine efficacy was seen as a likelihood for occurrence of polio cases among highly vaccinated children.

7. Inactivated Polio Vaccine Use a Policy Dilemma

The public health experts, academicians and scientists extensively discussed the relevance of introducing mOPV1 and its ineffectiveness in resolving the problem of the low immunity response of polio and high prevalence of polio cases among highly immunized children. The interest groups were consistently drawing of attention of government trivalent OPV was not effective in Indian context and low immune response is one of the major epidemiological risks for the success of the program. From on vast scientific data from around the world including India efficacy of IPV (three doses was found to be very high. Particularly in Indian context extensive studies done in 1980s even before launch of PPI program showed that IPV is best suited for Indian context. Inactivated polio vaccine (IPV) was widely studied and discussed by experts and scientists both nationally and internationally as more effective polio vaccine than OPV. The use of IPV was recommend as an alternative to use against OPV tropical regions particularly in high-risk areas as a means to interrupt the transmission of polio in endemic regions. But contrary to scientific research evidence on IPV in India OPV was chosen as vaccine to eradicate polio in by WHO and national government.

Based on scientific data discussions on use of IPV instead of OPV were well established outside government forums. There were continuous efforts by interest groups to influence the polio vaccination policy with continuous high demand to introduced inactivated polio vaccine (IPV) in polio program in India. But despite repeatedly directing attention towards the serious risk of ineffectiveness of OPV in building the necessary immune response at international of WHO, GPEI stakeholders, and at national level of government of India. The growing high

demand to introduce IPV as an alternative to OPV was overlooked by global and regional polio policy makers.

Due to growing demand of using IPV and consistent low immunity in endemic areas of western UP. After the 2006 outbreak policy options on understanding the operational feasibility of IPV as supplementary strategies were considered in critically high-risk areas. Directives were given by national polio experts committee to conduct study on understanding option of giving combination doses of IPV along with DPT (Diphtheria, Pertussis and Tetanus) to children in critically high-risk areas. The field-based studies were conducted to observe use of IPV as a supplementary strategy where small doses of IPV could close the existing immunity gap among children in areas where it is difficult to achieve adequate immunity levels despite multiple doses of OPV given in repeated SIAs rounds.

The use IPV within polio program was always seen as a challenge compared to feasibility in administering tOPV through mass immunization polio campaigns. But polio policy makers both globally and nationally in India were never in support on the use of IPV within the program. Debates on introduction of IPV in the PPI program were not supported globally by institutions such as WHO and UNICEF and nationally by IEAG. Contrary to various interests' groups advocating for policy change from OPV to IPV, use of IPV along with OPV in high-risk districts for reducing the risk of polio infection among children in high-risk areas and final interruption of poliovirus. The policy makers never saw any problem with efficacy of OPV and considered it as a core tool for completing the task of poliovirus elimination.

The need of using IPV was only considered as a means for limited use to boost children immunity against the poliovirus in areas where achieving high levels immune response was

difficult. Not as an end to improve overall immunity of children against OPV to finally interrupt the transmission of polio in the country. It remained as a means to provide individual protection to children to children in geographically limited endemic areas. But even such plans were increasing immune response among children as an endgame strategy in endemic districts were criticized by WHO from time-to-time as of less scientific interests.

Despite high demand on introducing IPV such policy change remained as a policy dilemma among health professionals, polio experts and policy makers at global level. At the national level in India questions on use of IPV were never taken positively by policy makers and highly criticized during the interviews. Against mOPV use of supplementary doses of IPV in India was not seen as considered as a supplementary strategy. There were several problems cited for policy shift on use of IPV from OPV as a core strategy of polio program. Operational challenges and logistics feasibility to operationalize IPV doses use as a plan was seen as a major problem. Overall, change of vaccine in high-risk districts was recognized as to add more confusion, more use of resources, highly expensive adding to high overall program cost, and the strategy would have limited role and impact. Extremely limited global supply of IPV, increase in vaccine procurement cost and use of more trained personnel to administer IPV was seen as to increase the overall cost of the program in use of IPV as a supplementary strategy in high-risk areas. Use of IPV along with OPV would have required a different vaccine delivery system, two cadre of human resources one for using OPV and IPV, there would be problem of implementing communication strategy to ensure community participation and acceptance of new vaccine along with OPV would have added to more confusion, difficultly in implementing and high program implementation cost. Thus, both increase in vaccine procurement cost and programmatic cost, confusion in managements and requirement of new techniques and resources were major concern on introduction of IPV along with OPV.

Apart from operational and logistics implementation level problems the overall strategy of using IPV in high-risk areas was considered not to had much impact. Although the high demand and need of on using IPV for high-risk districts was recognized by global policy makers the dilemma remained on effectiveness of IPV on solving the program challenges specially of high-risk districts of western UP. It was also well recognized that changing IPV would have not solved the low gut immunity problem among children in areas with high enterovirus incidence. As the poliovirus transmission in western UP was primarily through fecal-oral route. The use of IPV vaccine would have had limited impact on improving polio immunity and reducing polio cases. Further use of additional does of IPV as combination with DPT was consider difficult due to operational challenges to achieve high coverage for success of the supplementary strategy within the context of already low RI coverage in high-risk districts.

In 2009 evaluation study conducted by WHO in India on the situation of polio eradication and its challenges in India. The WHO team primarily focused its attention on understanding the ecology of poliovirus in state of western UP and Bihar to explain the existing challenges for eradication polio. The WHO team findings supported much of the earlier explanations considered by international polio experts, IEAG and government of India on reasons for low efficacy of tOPV in high-risk areas and constrains in eliminating poliovirus in northern states of UP and Bihar. The evaluation team findings acknowledge that there are unique environmental conditions in northern states of India responsible for circulation of poliovirus in the high-risk districts. Similar to other tropical developing countries trivalent OPV in states of UP and Bihar has limited immune response among children. But the WHO team denied any claims on high efficacy of IPV compared to ineffectiveness of tOPV in completing the eradication goal in India. The evaluation team strongly discouraged on plans to introduce

IPV as an alternative to OPV for increasing the immune response among children in high-risk districts. Use of IPV was seen as not a feasible option due to high operational cost and logistical needs against mass immunization polio campaigns. Supporting the fact that social determinants factors such as low gut immunity or high density as cause for continued circulation of poliovirus even after multiple doses of OPV. Efficacy of tOPV in eradicating poliovirus is not compromised despite limitations of tOPV polio as there is no distinctive evidence on low immunogenicity. A success is achieved in eradicating poliovirus with use of tOPV in majority of countries in the worlds. Similarly, it will be achieved in the states of UP and Bihar as tOPV over the years had reduced genetic diversity of poliovirus.

After WHO evaluation study demand of policy shift on using IPV as supplementary doses in India was not taken forward in India. Feasibility studies on using IPV as a supplementary strategy in India remained without any conclusive recommendations on effectiveness of IPV in geographically limited highly endemic districts of western UP where both type 1 and type 3 poliovirus were continually circulating. The IEAG in consistent with WHO evaluation findings supported that use of IPV has many operational and logistical challenges and the strategy would not have any impact in overcoming the challenges of high-risk areas in India.

Introduction of IPV was not seen as an alternative to OPV any further in India and the polio program continued with use of tOPV and changed the vaccine strategy to interrupt the high prevalence of type 1 poliovirus first followed by type 3 in high-risk districts of northern India. While from 2005 mOPV particularly for type 1 poliovirus remained central strategy for increasing population immunity in high-risk areas for children under five years of age. Tracking of new born children in high-risk areas and administering birth dose of mOPV was introduced after 2006 UP outbreak as an additional strategy in both institutional and non-

institutional births to improve immune response in highest risk areas among younger population. Particularly to build polio immunity among very young children in western UP high-risk areas.

Use of monovalent OPV in polio program had its own epidemiological and ethical implications in areas such as western UP with high prevalence of type 1 and type 3 polioviruses. The continued and exclusive use of mOPV1 as central strategy against use of mOPV3 in every SIAs round although reduced the immunity gaps of type 1 poliovirus. But at the same time, it increased immunity gaps of the type 3 poliovirus in endemic northern regions. The exclusive use of monovalent type 1 polio vaccine in high-risk district of western UP increased the risk of type 3 poliovirus infection among children and type 3 poliovirus spread widely away from endemic districts. With increase in immunity gaps from 2007 onwards the large number of cases of type 3 were reported from majority of districts in western UP compared to type1 polio cases reported.

The aggressive use of mOPV1 in SIAs and reporting of type 3 poliovirus cases added to confusion of community as their children were not protected from poliovirus infection despite giving polio doses. The polio program strategy of immunizing a smaller number of children with mOPV3 in SIAs rounds decline the high levels of transmission of type 1 poliovirus and increased the population immunity by mid of 2008 in the country.

But continued transmission of type 3 poliovirus cases was adding to the risk of polio infection among children. The vaccine strategy was again changed in 2008. The polio program switched to extensive use of mOPV3 along with mOPV1 in endemic districts of western UP and Bihar. The program strategy in second half of 2008 was using mOPV3 aggressively in

SIAs in endemic regions after controlling mOPV1. But the extensive use of vaccine remained low in SIAs throughout 2008.

But by the end of 2008 poliovirus transmission of type 1 was declining rapidly in India and the possibility of final interruption of poliovirus in India was not far from envision of program implementers. The stage was finally set for final interruption of poliovirus transmission in 2009. The focus of the program was exclusively to stop WPV1 transmission while keeping WPV3 suppressed particularly in high-risk districts and blocks of UP where both WPV1 and WPV3 transmission was continued. At this stage further switch in polio vaccine strategy was made and by the end of 2009 bivalent OPV (bOPV) was introduced in SIAs campaigns to interrupt both type 1 and type 3 polioviruses.

Until the final elimination of poliovirus in India advocacy on use of IPV remained as a policy dilemma among both providers of polio program and various interests' group. The use of IPV became part of polio free India polio program as part of WHO global switch program in 2015 to switch trivalent OPV (tOPV) to bivalent OPV (bOPV) and introducing inactivated polio vaccine (IPV) into routine immunization programme in all countries in 2016.

8. Final Phases of Eliminating Polio and Challenges

After the 2006 outbreak western UP became central focus of the program for addressing the critical challenges of the endemic areas with diversion of all attention and resources to few districts of western UP. Sustaining consistent high quality of SIAs along with efforts to reduce the immunity gap in young children through routine immunization high coverage remained focused. Addressing RI service delivery gaps and intensifying RI efforts in endemic districts of UP and Bihar were given continued high priority by National technical advisory group on immunization (NTAGI) formed by government of India. Along with strengthening of social

mobilization efforts emphasis was also given to reach continuously in every SIAs round vulnerable social groups such as nomads, slum population, migrant population through expansion of underserved and transit strategy. Role of local level human resources was increased to track the missed children in high-risk districts and blocks. The Union government of India along with partner organizations worked together to provide consistent local support to state governments in both UP and Bihar for ensuring high quality of SIAs in high-risk districts. Important step such as appointment and/or re-deployment of more experienced and best performing program staff for proper management and intensive monitoring of program was done to improve the overall quality of SIAs in high-risk districts. Further along with capacity building of vaccinations teams and supervisors' incentives were given to vaccinators and community for sustaining their motivation towards the program activities.

Exclusive and multiple SIAs campaigns using mOPV1 were implemented in endemic regions of UP and Bihar states. By mid of 2007 the program achieved substantial progress with high population immunity against the type 1 poliovirus and in the country including endemic districts of norther regions. Significantly there was decrease in poliovirus type 1 transmission in UP particularly in endemic districts western UP. In highly endemic district of western UP Moradabad for a period of six months no polio cases of type 1 poliovirus were reported. This was a milestone success for the program implementation in this area where continuous high-level transmission remained a critical challenge for past several years. By the end of 2007 the polio program in the country was considered to be completely evolved program. The program at this phase of implementation was capable to reach to the remotes areas in the country to deliver polio doses to eligible children. The polio surveillance system was fully developed identifying and defining accurately the poliovirus transmission in high-risk areas.

Throughout 2007 and 2008 the high population immunity gained in the country particularly in endemic districts against the type 1 poliovirus was sustained and transmission of type 1 poliovirus was limited to significant levels. India at this phase of program implementation was globally leading the global polio eradication efforts to interrupt type 1 poliovirus. The primary implementation strategy followed from 2007 mid onwards till complete elimination of poliovirus in India was to control and stop type 1 poliovirus transmission in endemic reservoir areas, maintain high immunity achieved so far and subsequently implement measures to control and suppress type 3 poliovirus transmission in western UP. Major emphasis was given to close the existing very high polio immunity gap in young children in endemic districts. Tracking of newborns was introduced during SIAs in UP and Bihar for enhancing the quality of program to reach all very young children in each and every SIAs round. Furthermore, specific efforts were put in endemic areas efforts were made to identify endemic pockets with under immunized children, improve the quality of general health service delivery, increase participation of ASHA workers for supporting both quality implementation of SIAs round and RI activities, vacant health workers position were filled at district and block level, three-fold increase in allowance of members of vaccination team, increase in communication and social mobilization activities to reduce proportion of missed children,

Implementation of large scale multiple sub-national rounds every year, continuous intensifying and improvement in quality of program efforts and consistent strategic changes appropriately viable for resolving specific challenges of endemic reservoir districts of UP and Bihar resulted in brink of ending type 1 poliovirus transmission in the country by the end of 2008. The possibilities of ending the poliovirus transmission at this stage of polio program implementation were very high and the all the attention was shifted to suppress the type 3

poliovirus transmission also to significant level through use of mOPV3 in endemic regions. More resources and focus on improvement in quality of program remained in high-risk blocks particularly in endemic areas of western UP and parts of central UP where both type 1 and type 3 poliovirus transmission was still going on.

Within the context where use of mOPV1 in endemic regions had reduced type 1 poliovirus significant levels in India WHO formed an evaluation committee to conduct an evaluation of polio program in India. The WHO team evaluated India polio program in 2009 focusing to understand existing constrain for polio eradication in India. Particularly evaluate tOPV low efficacy and ecology of poliovirus in endemic states and gave recommendations for improvement in the program and suggestions on strategic debates regarding use of tOPV against IPV. Based on WHO recommendation efforts within the polio program in India were intensified to address the existing programmatic gaps with particular focus on interrupting the poliovirus in endemic areas of UP and Bihar.

9. Last Miles to Complete Polio Elimination

From 2007 program continued its focus in high-risk endemic areas for the maintaining the progress achieved so far, ensuring improvement in SIAs quality, improvement in overall capacity of the program to reach young children, closer monitoring of SIAs rounds, and intensification of social mobilization activities to achieve change perception of community.

Before the final interruption of the poliovirus in India major efforts put into the program to improve the overall quality of the SIA rounds to ensure maximum coverage. Particular importance was given to intensify efforts to reach the last child with polio vaccine. Considering that the possibilities of ending polio virus transmission were increasing with very limited type 1 poliovirus transmission particularly in endemic states of UP and Bihar. Another switch in

polio vaccine was taken towards the end of 2009. Bivalent OPV (bOPV) was introduced in the PPI campaigns for suppressing both type 2 and type 3 poliovirus in endemic regions.

From 2007 onwards immunity of children particularly young children in endemic areas of UP and Bihar started improving to significant levels. Towards of the end of the program the overall SIAs quality remained very high particularly in high-risk areas of UP and Bihar.

For achieving the goal of elimination of poliovirus in India three main areas were given three main areas where the polio program gave significant emphasis for stopping the poliovirus in the country. 1) The final stage for stopping poliovirus circulation was set in India with control of type 1 poliovirus and program remained focused to suppress type 3 poliovirus and stop overall poliovirus circulation in endemic areas through use of bivalent OPV, 2) At the final stage of the program implementation major risk for missing circulation of wild poliovirus circulation were mobile and migrant populations carrying poliovirus from endemic reservoir areas to other polio free states. One of the major risk factors for spread and continued circulation of poliovirus outside of endemic areas at this phase of program implementation was mobile population migrating to states of Punjab, West Bengal, Haryana, Gujrat and Delhi and Maharashtra. Reducing the risk of poliovirus among large number of transient populations in endemic areas became critical for overall success of the program. Sustaining the high quality of SIAs in endemic areas and intensifying migrant strategy were given more priority. More focus was given to identifying and tracking mobile transient population in endemic areas of UP and Bihar and non-endemic areas. Major emphasis was given to strategies adequately tracking mobile and migrant population through their pattern of in-out movement from endemic areas, prioritize immunizing their children both in SIAs and in RI and ensuring better coverage and surveillance of migrant and mobile population, and 3) the persistence and continued risk of poliovirus transmission in highest risk endemic blocks of western UP and

central Bihar became a major impediment in obstructing the progress of the polio program in the country. Focus was given to reduce the risk of persistence polio virus transmission in highest risk endemic areas. For this purpose, in 2009 UNICEF designed 107 blocks strategy mapping all the highest risk blocks in both endemic states for rigorous improvement and implementation of underserved communication mobilization activities in these blocks. The strategy main emphasis was to overcome challenges in interrupting poliovirus transmission in highest risk blocks of endemic areas in western UP and central Bihar.

For the final push of polio eradication initiative in India major risks for missing circulation of wild polio virus circulation were migrant mobile population and risk of persistence polio virus transmission in highest risk endemic areas endemic reservoir areas. There were majorly two strategies emphasized

The final push given to stopping poliovirus in the country particularly in endemic regions through consistent vigilance to not miss circulation of poliovirus in highest risk endemic areas and mobile-migrant population resulted in historical reduction in number of polio cases in India by 2010. India by 2010 reached final phase of polio eradication because of lowest level of polio transmission recorded, no reporting of poliovirus both type 1 and type 3 cases from late 2009 and early 2010 in endemic reservoir areas of UP and Bihar, and immunity among children against type 1 and type 3 poliovirus reached to significantly higher levels particularly among very young children. The success achieved in endemic areas ensured the government and IEAG that poliovirus elimination in the country is in sight and the program will sooner be able to stop the poliovirus in the country.

The historic achievement recorded in 2010 with low levels of transmission of both WPV1 and WPV3 in both endemic reservoir areas of UP and Bihar along with rising immunity

was continued in 2011. The last case of polio was recorded in 2011 in West Bengal. After 2011 no cases of polio were reported from any part of the country and poliovirus transmission was consider to be on the verge of being eliminated from the country. The program remained vigilant to detection of any WPV in the country and in 2014 India was finally declared polio-free along with other WHO SEARO region countries.

CONCLUSION

India's success achieved in eliminating poliovirus from the country was commendable worldwide. For India, reaching the last child and eradicating polio in a diverse geographical and socio-cultural milieu was daunting and challenging. India's enormous success achieved during the beginning phases of the program implementation was globally recognized. But after earlier successes the polio program in the country became a continuous struggle until the last laps of program implementation for eliminating poliovirus in the country. The program struggles were predominantly centred around overcoming implementation-level challenges in two northern states UP and Bihar. India's success in turning over the page on poliovirus elimination is attributed to strong political leadership and intensive support of polio core partners and large numbers of health workers involved continuously with the program activities, continuously working hard to make India a polio-free country. Efforts were made to ensure sustained political commitment and ownership at each level of government management in the country for better program implementation. An integrated accountability structure at national, state and local government levels facilitated political leadership engagement and ownership of the program. Accountability of each person from the highest to the lowest levels was clearly defined to ensure sustained quality improvement in program activities. In the beginning, simplicity, intersectoral coordination, and community cooperation and participation were perceived as compelling reasons for its success. Simplicity, volunteerism and coordination by different cadres of human resources were some of the program's unique features. Since the beginning of the program, efforts have been made to make the pulse polio immunization program *a people's program.* However, the program evolved more technically after 2000. The growing contextual level operational, epidemiological, and socio-cultural problems in highly endemic areas of the northern states necessitated intensive use of innovative

strategic measures for achieving program effectiveness. The use of innovative strategies for ensuring quality and accountability of program implementers towards reaching every child in every SIAs rounds and providing the broader reach of polio messages to the most challenging and complex populations became central pillars for the program's success in the later phase. Aggressive mass media multi-pronged strategic approach used among the underserved, minority, and transient population enabled wider acceptance and reach of the program. Intensive community-level partnership with local leaders, influencers and religious, political and academic institutions facilitated more robust advocacy and acceptance of the program, particularly among marginalized minority communities.

Two of the uniqueness of the polio program, which made it different from other public health programs, were intensive branding of the program and translating research to policy and strategic program changes at each phase of implementation. Unlike other public health programs, the polio program was built as a brand which contributed to its enormous visibility and popularity among the communities' persuading communities and enabling their involvement within the program. The contextual problems the polio program encounters at the field level implementation of program activities were researched and then translated into policy changes at the national level and changes in program implementation strategies at the state level. The polio program changes enabled intensive efforts to reach the hardest-to-reach population with polio vaccines.

Although India's success in achieving polio-free status was commended globally and many of its innovative program strategies were replicated in other endemic countries. The repeated organization of cycles of SIAs for an extended period and continuous, exclusive focus of entire government machinery on pulse polio immunization resulted in experiences of frustration and social resistance among providers and the community. The polio program

implementation problems were not only operational management level problems. But also consist of socio-cultural problems in highly endemic states. Several of the problems encountered by implementers were because of the existing weakness in the health service system capacity at the state, district and block level.

By 2010 when poliovirus was on the verge of elimination in the country, the program could not increase the overall capacity of the health services system. There was low confidence among the country-level polio experts that poliovirus transmission could be stopped during the low season. The overall strategies used within the program were always considered by national level polio experts as correct and appropriate. All it was required was continue determination for achieving the eradication goals in the environment of continuous challenges in eliminating poliovirus in northern belts of India.

But the process of eliminating poliovirus become long, frustrating, and demotivating. The repeated frequency of polio rounds in India was frustrating and economically expensive for the global community, core program partners, and donors. The overall financial costs of the program and medical and human resources increased with continuous failures in stopping poliovirus transmission in endemic states of India. The repeated frequency of implementation of polio rounds, together with constant delays in ending the poliovirus transmission in the country, added to discouragement for all the people involved with the program. Despite government focus on implementing extensive plans for improving routine immunization services in endemic states. Routine immunization services continuously lagged behind the targets, and overall coverage remained low in the high endemic states of UP and Bihar. The evaluation conducted by WHO towards the end phase of the program implementation in 2009 also pointed out that RI services in both the endemic states of UP and Bihar are grossly inadequate to administer OPV doses to children. The need for robust RI services was critical

for earlier success in poliovirus interruptions and also for maintaining the overall program progress in the post-polio eradication phase in India. Throughout the program implementation, the RI services could not achieve high-level coverage in endemic states required for polio program effectiveness. The consistent missing of most infants and young children in RI immunization created a polio immunity gap among children which contributed to delays in the program's progress.

Major concurrent problems remained polio program encountered were logistical issues such as old and malfunctioning cold chains at district and block levels, lack of adequate complex chain maintenance, vaccine insecurity, and insufficient funds. India's government had to continuously struggle to fill the funding gap required for vaccine and operational costs through mobilizing funds from external and internal resources. The timely availability of polio doses continued to be a frequent problem for conducting SIAs effectively and on time. Changing communities' perception with the intensification of social mobilization activities, particularly addressing the social determinants of health in the endemic areas, was recognized much later within the overall program implementation.

Although the polio program was popular in the endemic states of UP and Bihar, growing community resistance, resentment and lack of trust became a persistent implementation problem. The significance of building community trust in government health systems to avoid community fear and social resistance towards health policies is an essential social health determinant in health care delivery and health policy approach.

The highest public health strategy is eradicating diseases for the better survival of the human population and wellbeing. However, there are epidemiological criteria for selecting the conditions for eradication. In some diseases, the natural history does not allow for eliminating

viruses from the human environment. Apart from its natural history, a disease has to become a priority for global eradication based on its feasibility, not on the availability of eradication tools. Like polio, measles was a more dreadful disease to be prioritized for eradication. The world already had the measles vaccine available, but polio which became an international priority for eradication.

The world health organization started the polio eradication program in 1988, promising to eradicate the disease in 10 years. However, the program in India took two decades to eliminate the polio virus, and polio is still endemic in two countries. Polio eradication, recognized as an achievable goal in developed countries, became difficult in India, particularly in the northern regions of Uttar Pradesh and Bihar.

The two states became the endemic reservoirs of polio infection, fueling the nationwide poliomyelitis outbreak. Polio vaccines showed a variant nature in northern regions. The failure of the polio eradication program in reducing high polio incidence and the high number of VAPP cases questioned the overall safety and effectiveness of OPV in the country.

The OPV-associated problems and risk factors were ignored in India in the planning and implementation of the program, despite substantial research evidence available. It also resulted in suspicion of the polio immunization campaign among the deprived, marginalized communities.

The problems encountered in implementing the polio eradication program and consequently changes in polio program strategies several times resulted in achieving the polio-free status in India in 2014.

For the many people in developed countries, it is an unknown fact that in the other part of the world, polio still infects children, and many children still bear its traces as disability.

There is considerable confusion about the polio journey ahead. As the polio eradication program remains in operation in the remaining two endemic countries and in other polio-free countries, some uncertainty persists until the final global eradication certification. The global shortage of IPV vaccine, outbreaks and risk of re-infection in many polio-free countries, and challenges in long-term financing of international polio program are some significant problems to be considered for achieving the global eradication goal. The promise of building a sustainable health system is still to be fulfilled by the global health community in developing countries. The measles elimination program in India is the following diseases on the list of eradication.

> "With the success of polio eradication, the next focus should be on eradication of Measles (it can be eradicated because of easy case identification, known epidemiological features of the disease, a potent vaccine with a long period of immunity)." [783]

Considering the challenges in polio elimination in India, it is important to critically reflect on the choose to eradicate diseases as the ultimate goal of any global policy on infectious disease. Also, it is imperative to review the history of disease eradication initiatives to learn on how diseases eradication was beneficial for improving the population's health and with only use of vaccines as a central strategy.

[783] Interview

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