International Journal of Health Sciences and Research
www.ijhsr.org ISSN: 2249-9571

Review Article

Poliomyelitis Eradication: Achievements and Challenges

Varun Malhotra
Army Medical Corps
Colonel Medical, HQ 1 Armoured Division, C/O 56 Army Post Office, India

Correspondence Email: varun_1955@yahoo.com

Received: 08/05//2012 *Revised: 30/05/2012* *Accepted: 2/06/2012*

ABSTRACT

Since 1988, when World Health Assembly passed a resolution to eradicate Poliomyelitis from the planet, number of endemic nations has decreased from 125 to 3, and polio cases by 99 percent. However, polio eradication is not a game of numbers. This article discusses the achievements, challenges and modified strategy adopted by Global Polio Eradication Initiative to eliminate the remaining foci of infection. Unlike Smallpox, the battle against polio will continue even after eradication of 'agent', as the attenuated viruses being used for eradication themselves are capable of developing neuro-virulence and cause polio, not only in vaccine recipients, but also outbreaks in community. The virus also has also shown its capacity to survive in environment, and in primary immuno-deficient persons. Thus, immediate post eradication era will need as much resolution and resources as during pre-eradication period. The paper briefly mentions the strategies that are being developed for prevention and control of vaccine derived poliomyelitis during post eradication era.

Key Words: Wild Polio Virus, Oral Polio Vaccine, Inactivated Polio Vaccine, Vaccine Associated Paralytic Polio, Vaccine Derived Polio Viruses, Global Polio Eradication Initiative, Post Eradication Era

INTRODUCTION

The forty-first World Health Assembly in 1988 adopted a resolution for the worldwide eradication of polio. It marked the launch of the Global Polio Eradication Initiative (GPEI). The strategies, recommended by GPEI, and adopted by National Polio Surveillance Project (NPSP), a Government of India-WHO Collaboration are; attaining high herd immunity by immunizing every child aged less than one year with at least 3 doses of oral poliovirus vaccine (OPV); supplemental Immunization Activities (SIAs); surveillance of acute

flaccid paralysis (AFP) cases, and "mopping-up" operations. [1]

Progress

Global

Polio cases have decreased by over 99% since 1988, from an estimated 350 000 cases every year in more than 125 endemic countries then, to 1352 cases in 2010, 650 during 2011, and 60 till 25 May 2012 (Table 1). Only three countries (Afghanistan, Nigeria and Pakistan) in the world remain endemic for the disease - the smallest geographic area in history. Since 1988, an estimated eight million children who would otherwise have been paralyzed are walking *tall* because of the GPEI. In addition to its march towards its own goal, the programme has many spin-offs. Through polio eradication efforts, a significant investment has been made in strengthening health service delivery systems in many countries. By building effective surveillance systems, training local epidemiologists and establishing a global laboratory network, GPEI has expanded the capacity to tackle other infectious diseases, such as avian influenza or Ebola. This capacity has also been deployed in health emergencies such as the 2010 floods in Pakistan and the 2011 drought in the Horn of Africa. Routine immunization services have been strengthened by bolstering the cold chain, transport and communications systems for immunization. Improving these services has helped to lay the groundwork for highly successful measles vaccination campaigns, and Vitamin A administration during SIAs. Through the synchronization of SIAs, many countries have established a new mechanism for coordinating major cross-border health initiatives aimed at reaching all people – a model for regional and international cooperation for health. [2]

India

During mid 1990s, when eradication activities were initiated in India, an estimated 50,000 polio cases were occurring each year. By 2006, transmission of indigenous wild poliovirus (WPV) had been interrupted in all countries except India, Afghanistan, Pakistan, and Nigeria. During 2006—2009 India annually reported 559 to 874 cases of confirmed WPV, with cases centered in the northern states of Uttar Pradesh and Bihar. These cases accounted for 43% of confirmed cases of WPV reported worldwide during this period. However, in 2010, 42 WPV cases, and in 2011, only one WPV case had been confirmed in India. On 13 January 2012, India reached a major milestone in the global battle against polio, recording a full year without a single case of the virus in the country that was long its epicenter and biggest exporter. India is polio free since 13 January 2011 [3] and has been excluded from the list of polio endemic nations. [4]

The challenges ahead.

In spite of enormous progress, tackling the last 1% of polio cases is proving to be difficult and expensive. Persistent pockets of transmission in the endemic countries are key challenges as they continue to export the poliovirus to polio-free areas and countries. In a few countries, sustained poliovirus transmission for over 12 months, after importation has resulted in 're-established transmission'. Conflict, political instability, hard-to-reach populations, and poor infrastructure continue to pose challenges to eradicating the disease. Increased funds from the international donor community and continued political commitment from the remaining polio-affected countries are essential to finish the job.

Table 1

POLIOMYELITIS 2010 & 2011 and 2012 (till 25 May 2012) [5]

Country/year	2010	2011	2012
Pakistan	144	198	16
Afghanistan	25	80	6
Nigeria	21	61	35
India	42	1	-
DR Congo	100	93	-
Chad	26	132	3
Angola	33	5	-
CAR	-	4	-
Cameroon		1	-
Niger	2	5	-
China	-	21	-
Guinea	-	3	-
Kenya	-	1	-
Cote d'lvoire	-	36	-
Mali	4	7	-
Congo	441	1	-
Gabon	-	1	-
Uganda	4	-	-
Russian Federation	14	-	-
Liberia	2	-	-
Nepal	6	-	-
Kazakhstan	1	-	-
Tajikistan	460	-	-
Turkmenistan	3	-	-
Senegal	18	-	-
Mauritania	5	-	-
Sierra Leone	1	-	-
Total	1,352	650	60
Total in endemic countries	232	341	57
Total in non endemic countries	1,120	309	3

Independent Monitoring Board of the GPEI in its report published in October 2011 has also emphasized the need to ensure continued motivation of 'human resource' involved in polio eradication. [6] Even the strategy of using OPV for eradication of remaining foci of infection, as recommended by GPEI, and adopted by NPSP is being questioned. The main challenges in global march towards achieving the criteria of eradication are:-

(a) Sustaining Immunity through Routine Immunization, Conducting Quality NIDs /SNIDS and Ensure Community Participation through Social Mobilization. Success of polio elimination depends on meticulous programme planning, intensive supervision, monitoring and extensive social mobilization. The significance of sustaining immunity of successive birth cohorts through routine immunization and PPI programme is vital for all endemic nations. However, for endemic nations of Asia it has gained added significance because of a recent development in the field of polio eradication, namely the evolving epidemiology of polio has demonstrated that the population immunity thresholds needed to interrupt WPV transmission are higher (>95%) in Asia than Africa (80-85%). [7] Eliminating WPV requires high vaccination

coverage with special focus on marginalized and migrant populations, an objective that deserves whole hearted support of all stake-holders.

(b) Acute Flaccid Paralysis (AFP) Surveillance & Moppping Up. AFP surveillance is the 'gold standard' for detecting cases of poliomyelitis, and it underpins the entire polio eradication initiative. The objective of AFP surveillance is to detect the exact geographic locations where wild polioviruses are circulating in the human population. All cases of AFP in children aged <15 years are rigorously investigated by a trained medical officer, with collection of stool specimens to determine if poliovirus is the cause of the paralysis. Analysis of polioviruses isolated from AFP cases allows programme managers to plan immunization campaigns to prevent continuing circulation of virus in these areas. High quality of AFP surveillance in India has been responsible for spectacular achievements; the need to replicate the processes in other endemic countries needs no emphasis.

(c) Importation of WPV. WPV has shown a capability to reach pockets of inadequately vaccinated children. As China, Congo, the Russian Federation and Tajikistan have learned, the poliovirus does not respect national borders. During 2010 and 2011, 82.84 and 47.61 percent of all polio cases occurred in non-endemic countries. To minimize the risk of outbreaks from importation, all polio free countries including India must maintain high population immunity level. Interestingly, the risk of importation to India is higher from Africa than from Pakistan. Genetic mapping of WPV has revealed that polio virus has not crossed the Indo-Pak border since Independence. However, India has to be vigilant on all fronts. OPV is being administered to all children < 5 years of age arriving from Pakistan through Amritsar. Surveillance for polio has been intensified through active case search in Punjab, Rajasthan, J&K and Gujarat that share common border with Pakistan. [8] However, international airports remain vulnerable entry points; because of diplomatic reasons OPV is not yet being given to entrants arriving by air.

(d) Vaccine Associated Paralytic Poliomyelitis (VAPP) and Vaccine Derived Poliomyelitis Virus (VDPV). The risks of development of neuro-virulence by attenuated viruses, and their capability to cause disease in some vaccine recipients, or naïve contacts were known in 1961, when the Sabin vaccine was licensed in the United States. [9] However, these risks of OPV at the time were considered minimal compared to the enormous potential benefits of a vaccine that stimulated immunity similar to natural infection, cost little, and offered hopes for global poliomyelitis control. The first serious outbreak of vaccine-derived polio was in Haiti and the Dominican Republic in 2000, six years after the WHO certified the Americas polio-free. The episode shocked the eradication community, but it was soon followed by another in Nigeria. VAPP cases are extremely rare; risk of vaccine-associated paralytic poliomyelitis (VAPP) is approximately 2-4 per one million birth cohort. VAPP results from small genetic mutations which the live vaccine-virus undergoes when replicating in human gut. Rarely the attenuated OPV viruses can genetically change from OPV strain to become a circulating vaccine derived polio viruses (cVDPVs), regaining ability to cause paralysis, as well as to circulate, similar to WPVs. During past decade, over 10 billion doses of OPV have been administered to more than 2.5 billion children preventing more than 3.5 million polio cases. During this period, 18 outbreaks of cVDPV resulting in 510 VDPV cases have occurred. [10, 11]

(e) Wild Poliovirus (WPV) Transmission in Endemic Countries. Today, Polio is more geographically restricted than ever before. The highest priority is reaching all children during SIAs in the endemic countries. Presently, access

remains eradication's biggest problem. It is hard to get to all susceptible children, particularly in war-ravaged nations such as Pakistan and Afghanistan. To succeed, high levels of political commitment have to be maintained at national, state/provincial and district levels.

(f) Re-established Transmission. Three countries- Angola, Chad and the Democratic Republic of the Congo – have been classified as having 're-established transmission' because they have had ongoing transmission for over 12 months. These countries deserve same priority of activities as the endemic countries.

(g) Financial Constraints. Substantial financial resources are required to support polio eradication. Success in carrying out the necessary vaccination campaigns and surveillance hinges on sufficient funds from financial stakeholders. Full implementation of the GPEI Strategic Plan 2010-2012 will require the mobilization of US $750-800 million per year for planned activities. [(12)]

(h) Socio-cultural Factors. The immunity gap in northern Nigeria is the legacy of a suspension of poliovirus immunization activities in 2003 and 2004, the community's lingering suspicions about the motivations of public officials, and rumored risks of HIV infection and infertility associated with the vaccine. [(13)] Despite the optimism that marked the resumption of immunization activities, ongoing political, cultural, and religious objections hinder vaccination efforts, resulting in persistently low immunity in the population. Northern Nigeria has had ongoing WPV transmission because of a weak health-system infrastructure and programmatic limitations such as poor implementation of SIAs. Nigeria has been a major reservoir for WPV transmission to other countries. [(14)]

(i) Immune-deficiency associated VDPVs. Another risk associated with OPV use is chronic VDPV excretion by people with primary immune deficiency including severe primary B-cell immune disorders. These people with such infections may excrete virulent virus for years. [(15, 16)]

(j) Challenges with OPV. OPV virus has also been detected in environment, [(17)] and found ineffective in some children in India, who had received even 15 doses of the tOPV, probably because of diminished immune responses due to a high prevalence of diarrhoeal illness at the time of vaccination, competing enteric viruses and competition of type 2 with types 1 and 3 vaccine viruses. [(18)]

No one denies that the oral vaccine has considerable merits. It is cheap, easy to administer; and requires just a volunteer with a dropper. In addition, it gives excellent immunity, both humoral and mucosal that even spreads to other people in the community, further disseminating resistance. However, the balance of benefits of OPV starts tilting against it, when the WPV is eliminated from an area/ Nation or WHO Region. More than a decade ago, the developed world returned to Salk's inactive vaccine. Various alternatives to OPV are, to use IPV during the interval between the cessation of wild virus transmission and the global stoppage of polio vaccination; [(18)] a simultaneous administration of IPV and OPV at 6, 10 & 14 weeks of age, [(19)] or IPV at 6,10 & 14 followed by OPV during SIAs. [(20)]

GPIE Strategic Plan 2010-2012.

Alarmed that polio remained entrenched in the four countries that had never stopped transmission, and that an increasing number of polio-free areas were becoming reinfected, the World Health Assembly in 2008 called for a new strategy to complete polio eradication. The GPEI 2008 was subsequently upgraded by Programme of Work in 2009. The new GPEI Strategic Plan 2010-2012 [(21)] builds on the 2009 Programme of Work and incorporates the myriad lessons learnt since 1988. Four major lessons that had substantive implications for the GPEI Strategic plan

2010-2012 were the knowledge that immunity thresholds to stop polio differ, being higher in Asia than Africa; Optimizing the balance of mOPVs is much more difficult than anticipated; routes of poliovirus spread & outbreaks are now largely predictable, and immunity gaps allow virus to persist in smaller areas & sub-groups than thought. Based on these lessons the modifications in GPEI Strategic Plan 2010-2012 are:-

(a) Bivalent OPV. First licensed in 2009, this new vaccine offers substantial programmatic advantage by simultaneously generating immunity to both of the remaining WPV serotypes (types 1 and 3) which is 35%-40% higher per dose than that of trivalent OPV and similar to that of the respective monovalent OPV. The large-scale use of bivalent OPV in SIAs is complementing the continued use of trivalent OPV in some SIAs and in routine immunization, as well as of monovalent OPVs in some mop-ups and SIAs where appropriate. [21]

(b) State/district/block-specific plans. The development of area-specific plans proved critical to finally establishing a consolidated approach to addressing the chronic and often unique operational challenges in a number of endemic areas. [22]

(c) Sub-national advocacy. In a number of countries, including Pakistan, Nigeria and India, new mechanisms and criteria have been developed to measure and track the engagement of sub-national (e.g. state/province, district, union-council levels) political and administrative leaders to ensure that full resources of state/provincial governments are applied to improve SIA performance and accountability. [22]

(d) The Short Interval Additional Dose (SIAD) strategy. SIAD enables a more rapid rising of population immunity levels, by administering two doses of monovalent oral polio vaccine (mOPV) in quick succession. This approach has proved particularly valuable in areas where populations may be difficult to reach, such as in conflict-affected areas or among nomads. [22]

(e) Expanded environmental sampling. The expansion of environmental sampling to areas such as Karachi and Lahore (Pakistan) reaffirmed the utility of this tool in endemic areas, particularly to differentiate reservoir areas from areas that are repeatedly re-infected. [22]

(f) Area and issue-specific research. Operational research that is tailored to the specific challenges of each remaining endemic area will be applied more systematically in 2010-2012. [22]

(g) Special teams and tactics for underserved populations. Special teams and tactics have proven to be essential for addressing the special needs of some population subgroups (e.g. nomads, migrant labourers) and communities. [23]

(h) Monitoring of SIA coverage. The gap in credible and timely SIA coverage data to assess risks and guide improvements has been a continuing constraint, in both endemic and in re-infected countries. From 2010, the results of independent SIA monitoring are being internationally posted within two weeks of each campaign. Areas identified as having <90% coverage will be immediately re-covered, with corrective measures implemented in advance of the subsequent SIA. [24]

(i) Serologic surveys. Serologic surveys are likely to prove valuable to document programme status, assess prospects and adjust plans by more accurately determining population immunity. [25]

(i) Enhanced AFP surveillance. In 2008-2009, major progress was made in closing persistent gaps in acute flaccid paralysis (AFP) surveillance by enhancing the scrutiny of standard performance indicators, conducting targeted surveillance reviews and deploying additional human resources to priority areas such as Chad and southern Sudan. This experience will guide further investments in 2010-2012. [26]

(j) Enhancing communications/ social mobilization in priority areas. The use of AFP and SIA data to systematically identify underserved and under-immunized populations for accurate targeting, and enhancing effectiveness through communications interventions in identifies areas. [27]

(k) Rehabilitation of polio-affected individuals. To help address the problem of isolation and discrimination, the GPEI will improve access to rehabilitation services. [28]

The relative importance and emphasis of each of above common operational approaches will be tailor made for each country, depending on the local programmatic barriers to reaching all children with OPV, and interrupting WPV transmission.

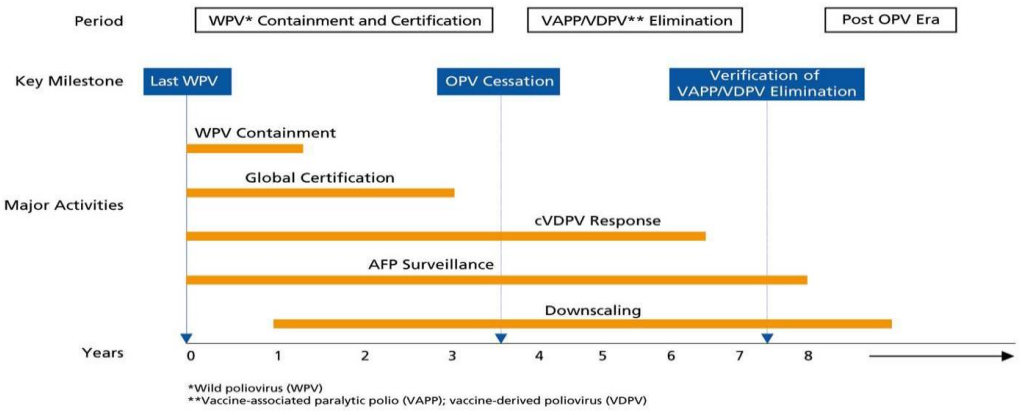
Post-eradication - preparing for a lasting polio-free world

Although there is still much distance to cover to eradicate the remaining wild polioviruses, recent progress has generated new confidence in the eradication effort, and talk of the polio "endgame" has intensified. However, unlike Smallpox eradication, preventing polio outbreaks in a "post-eradication era" will require more than bio-containment measures to prevent the reintroduction of wild virus from laboratory stocks or sites where inactivated (Salk) polio vaccine (IPV) is produced. Achieving a polio-free world will eventually require stopping routine immunization with OPV and eliminating vaccine-derived polioviruses (VDPVs), particularly circulating VDPVs, which are Sabin-strain viruses that have acquired both neuro-virulence and the capacity to circulate. [29, 30]

OPV cessation

In 2008, appreciating the risks posed by VAPP and VDPVs as wild poliovirus transmission is brought to a halt, the World Health Assembly requested the Director-General of WHO to accelerate the programme of work on post-eradication risk management, including establishing a timeline (Fig 1) for the eventual cessation of OPV. The risk of VAPP and VDPVs is operationally acceptable until WPV transmission is widespread. Obviously, a time will come when balance of benefit versus risk of OPV would begin to tilt. Globally, that will occur around the time of interruption of WPV transmission. That is why the cornerstone strategy for immediate post–eradication era is to eliminate the risks of VAPP and cVDPV due to OPV by stopping use of live vaccine. With OPV cessation, the risk of new cases of VAPP or VDPVs would be eliminated. However, the challenge will be to synchronize OPV cessation globally, and manage the risks in the transition period between OPV cessation and the elimination of any residual VDPVs. [31]

Timeline for OPV cessation [32]



Improving IPV

Cessation of OPV will eliminate VAPP, but elimination of residual cVDPV will necessitate maintaining the herd immunity against polio by switching to inactivated polio vaccine (IPV). Recognizing that cost of current IPV is substantially higher than OPV, GPEI is promoting research on development of affordable IPV. Four approaches undertaken in this regard are: antigen reduction using adjuvant ; schedule reduction by two IPV doses to immunize , dose reduction by using fractional dose of IPV given intra-dermally, [(33)] and reduction of production cost by optimizing production processes, and producing IPV with less or noninfectious strains. Results of research in all these approaches are encouraging. It may be historically interesting that Sabin seed strains may still be a major armamentarium during OPV cessation era, as Netherlands Vaccine Institute has produced IPV from killed Sabin poliovirus. This vaccine has the advantage over Salk vaccine, that attenuated viruses are safer to handle and require less stringent manufacturing standards, thus decreasing production costs. [(34)]

Anti Virals

The other option to address risks of emerging VDPV is treatment with antiviral drugs. Dozens of antiviral compounds mainly capsid and protease inhibitors have been tested for activity against polioviruses, with two promising candidates now in pre-clinical development. Such antiviral could play a key role in ensuring that infections are rapidly cleared in immunodeficient individuals who might be chronically shedding poliovirus. At the same time, antiviral could offer protection for persons accidentally exposed to poliovirus (e.g. laboratory accidents) and for communities exposed to cVDPVs. [(35, 36)]

OPV stockpile

WHO has made progress in developing an OPV stockpile to respond to residual cVDPVs. By the end of 2010, nine monovalent OPVs (for type 1 and type 3 polio) had been licensed, and a global stockpile that will be critical to carry out timely response to any residual cVDPVs in the post-eradication era is under tender.

International coordination in the post-eradication era

With greater knowledge and new tools, the policy requirements for a post-eradication era are becoming clearer, particularly on those aspects requiring international coordination namely synchronized OPV cessation, containment of all polioviruses, and policy for the use of OPV in response settings.

CONCLUSION

The world is on the threshold on eradication of a disease that causes *deaths, disability, disfigurement, de-humanization and discrimination.* [(37)] Once polio is eradicated, the world can celebrate the delivery of a major global public good that will benefit all people equally, no matter where they live. Economic modeling has found that the eradication of polio in the next five years would save at least US$ 40-50 billion, mostly in low-income countries. Failure to eradicate polio would have serious consequences for public health. It would lead to a major resurgence of the disease, with over *250,000 children crippled for life again every single year*. At the same time, it would represent the most expensive public health failure in history, with far-reaching consequences for overall global immunization efforts, seriously undermining the credibility of public health endeavors with donors and stakeholders. [(38)]

Most of us could not be participate in Small pox eradication. We should not miss this unique opportunity, of being a part of historic moment when our planet will be free of poliomyelitis for all future generations; an inheritance they would be grateful for.

REFERENCES

1. Eradication Strategy: National Polio Surveillance Project. URL http://www.npspindia.org/Eradication%20Strategy.asp
2. Poliomyelitis WHO Media centre Fact sheet. URL http://www.who.int/mediacentre/factsheets/fs114/en/
3. Denyer S, Washington Post dated January 12, 2012. URL http://www.washingtonpost.com/world
4. WHO takes India out of polio-endemic countries' list. Indian Science Journal dated 25 Feb 2012. URL http://indiansciencejournal.wordpress.com/2012/02/25/who-takes-india-out-of-polio-endemic-countries-list
5. Polio this week: as of 14 Mar 2012. GPEI; Data and Monitoring. URL http://www.polioeradication.org/Dataandmonitoring/Poliothisweek.aspx
6. IMB Meeting Report. URLhttp://www.polioeradication.org/Aboutus/Governar
7. Major Lessons Learnt, Chapter 2.1 of WHO, UNICEF, CDC (2010) Global Polio Eradication Initiative, Strategic Plan 2010-12. URL http//www.polio eradication.org-Portals-0-Documents-strategic Plan 2010_2012
8. Aarti Dhar, Polio: challenge far from over; The Hindu dated 23 Feb 2012 URL http://www.thehindu.com/news/national/article2924438.ece
9. Sabin AB. Recent studies and field tests with live attenuated poliovirus vaccine. Paper presented at the First International Conference on Live Poliovirus Vaccines, Scientific Publication 44. Washington, DC: Pan American Sanitary Bureau,1959:14-33.
10. Sir Smith J, Leke R, Adams A, Tangermann RH. Certification of polio eradication: process and lessons learned, Bull World Health Organ 2004 Vol 82 No 1
11. OPV cessation, time to proceed by individual serotypes? Polio Pipeline No 8, summer, 2011
12. Financial resource requirements 2011-2012. GPEI Document. URL http://www.polioeradication.org/Resourcelibrary/Strategyandwork/Financialresourcerequirements.aspx
13. Pallansch MA, Sandhu HS. The Eradication of Polio-Progress and challenges: N Engl J Med 2006; 355:2508-11
14. Progress Toward Poliomyelitis Eradication- Nigeria, January 2010--June 2011: CDC Morbidity and Mortality Weekly Report (MMWR) August 12, 201; 60(31);1053-57
15. Sutter RW, Prevots DR. Vaccine-associated paralytic poliomyelitis among immunodeficient persons. Infect Med 1994; 11:426,429-38.
16. New knowledge of prevalence of iVDPVs, GPEI Polio Pipeline No.8 - Summer, 2011
17. Shulman I, Manor J, Handsher R. Molecular and antigenic characterization of a highly evolved derivative of the type 3 oral polio vaccine strain isolated from sewage in Israel. J Clin Microbiology 2000; 38: 3729-34
18. John TJ Anomalous observations on IPV and OPV vaccination Dev Biol 2001;105:197-208.
19. Collaborative Study Group on Oral and Inactivated Poliovirus Vaccines. Combined immunization of infants with oral and inactivated poliovirus vaccines: results of a randomized trial in The Gambia, Oman, and Thailand. Bull World Health Organ 1996;74: 253-68.
20. Lahariya C. Global eradication of polio: the case for "finishing the job"

Bulletin of the World Health Organization. Bull World Health Organ 2007 Vol 85(6)
21. Programmatic benefits of bivalent OPV - 'from bench to bush!'. GPEI Polio Pipeline No 6, Summer 2010
22. Common operational approaches, Guiding principles, WHO, UNICEF, CDC (2010) Global Polio Eradication Initiative, Strategic Plan 2010-12. URL:http//www.polioeradication.org -Portals-0-Documents-strategicPlan 2010_2012
23. Courtyard women strategy: innovative approach to community outreach in conflict-affected areas of Afghanistan. GPEI Polio Pipeline No.4 Summer 2009
24. The use of LQAS to assess polio immunization coverage in Nigeria. GPEI, Polio Pipeline No.5 Winter 2010.
25. Seroprevalence surveys to guide programmatic action. GPEI Polio Pipeline No 2 Autumn 2008.
26. Developing and evaluating tools to improve AFP surveillance management. GPIE Document. URL http://www.polioeradication.org/Research/Surveillanceresearch.aspx
27. Mobile phones help assess quality of polio campaigns. GPEI Polio Pipeline No 7 Winter 2011
28. Polio survivors not left stranded by eradication efforts. GPEI Annual Report 2010. Chapter 3 Strategic Plan 2010-2012; 12.
29. Managing transition period after OPV cessation. GPEI, Polio Pipeline No.8 - Summer, 2011
30. Aylward B, Yamada T. The Polio Endgame: N Engl J Med 2011; 364:2273-75.
31. Sutter RW, Cáceres VM; Lago PM, The role of routine polio immunization in the post-certification era Bulletin of the World Health Organization Vol 82 No 1 . URL http://dx.doi.org/10.1590/S0042-96862004000100008.
32. Time line for polio eradication. GPIE document 2010. URL http://www.polioeradication.org/Posteradication/OPVcessation/Timeline.aspx
33. Resik S, Tejeda A, Lago PS, Diaz M, Carmenates A, Sarmiento L,et al. Randomized Controlled Clinical Trial of Fractional Doses of Inactivated Poliovirus Vaccine Administered intradermally by Needle-Free Device in Cuba. Vaccine 2010:28(22): 3778-83
34. Improving IPV. GPIE Polio Pipeline No 1 Summer 2008
35. De Palma AM, Pürstinger G, Wimmer E, Patick AK, Andries K, Rombaut B, et al. Potential use of antiviral agents in polio eradication. Emerg Infect Dis 2008. URL http://wwwnc.cdc.gov/eid/article/14/4/07-0439.htm.
36. Antivirals. GPIE document. URL http://www.polioeradication.org/Research/Antivirals.aspx
37. Malhotra V. Lessons from Observation of Supplementary Immunization Activity in India. *Online J Health Allied Scs*.2012;11(1):11. URL: http://www.ojhas.org/issue41/2012-1-11.htm
38. Post-eradication - preparing for a lasting polio-free world GPEI,Polio Pipeline No.8 - Summer, 2011

****