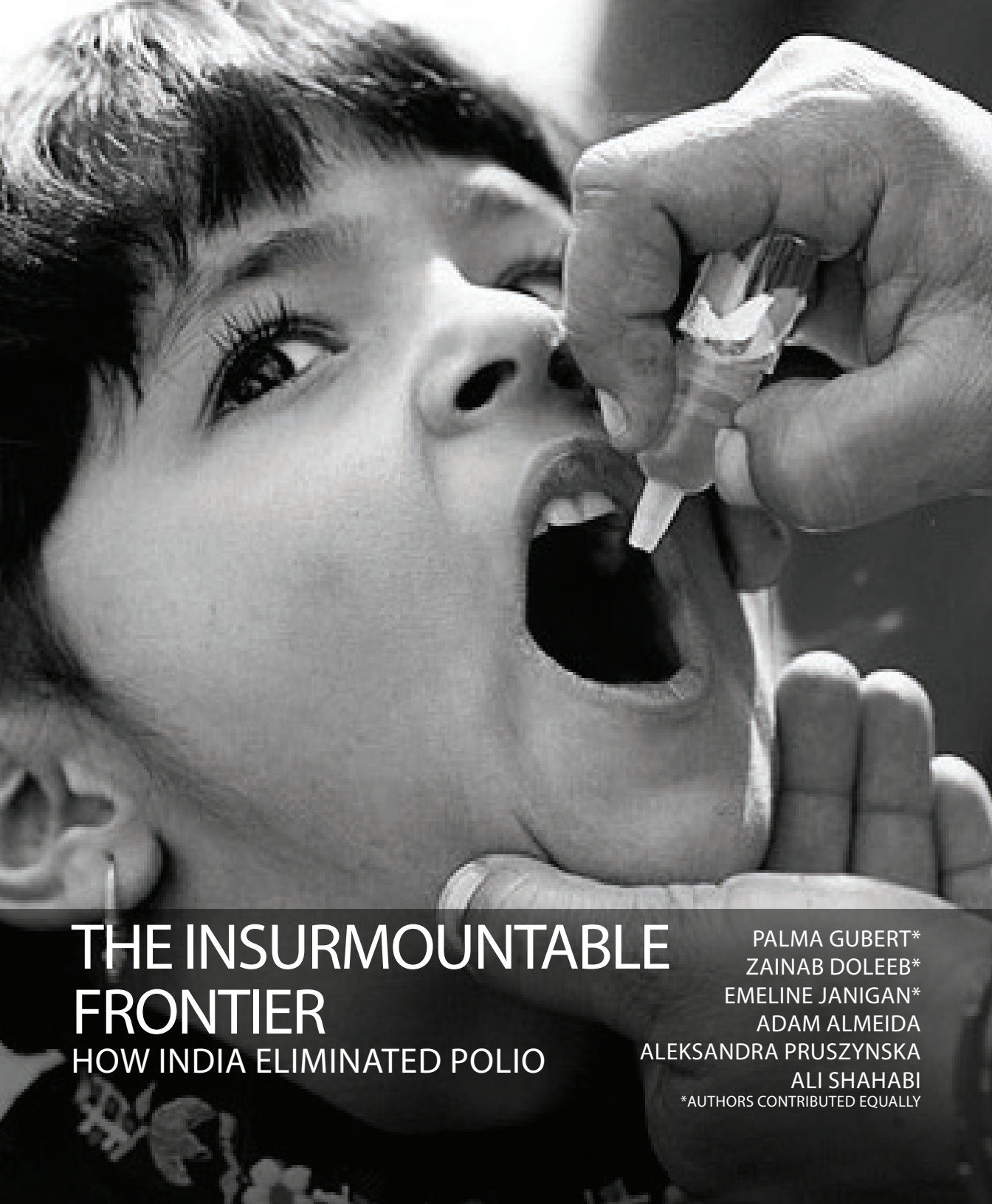

THE INSURMOUNTABLE FRONTIER

HOW INDIA ELIMINATED POLIO

PALMA GUBERT*
ZAINAB DOLEEB*
EMELINE JANIGAN*
ADAM ALMEIDA
ALEKSANDRA PRUSZYNSKA
ALI SHAHABI
*AUTHORS CONTRIBUTED EQUALLY

This case study evaluates India's efforts to eliminate all poliovirus strains in the country. This was done through massive immunization campaigns that targeted specific and marginalized groups, public awareness campaigns, and an emphasis on nation-wide surveillance. Ultimately, polio was successfully eliminated in India and the country averted 1.48 billion disability-adjusted life years. The number of cases declined from 200,000 in the 1970s to 400,000 in the 1980s, and finally to zero cases in 2012. This case owes its success to political will, coordinated inter-sectoral collaboration, significant funding (over US$2.4 billion from multiple contributors), and persistent efforts to immunize all children.

Background

Poliomyelitis ("polio") is an infectious virus that can lead to paralysis or death. There are three serotypes of the wild poliovirus (WPV): WPV1, WPV2, and WPV3. Although polio is incurable, vaccines have helped to eliminate the virus in most countries around the world. In 1953, when 35,000 children per year in the United States were being disabled by polio, Jonas Salk developed the inactivated poliovirus vaccine (IPV). As a result, incidence of polio in the United States fell by 85 to 90% between 1955 and 1957. In 1962, another breakthrough occurred when Albert Sabin produced the oral poliovirus vaccine (OPV), which was less expensive and logistically easier to administer (1).

The global success of polio vaccination quickly became evident. By 1988, polio had disappeared from the United States, the United Kingdom, Australia and much of Europe, but remained prevalent in more than 125 countries. The World Health Organization (WHO) certified Latin America polio free in 1994, the Western Pacific region (including China) by 1997, and all of Europe by 2002 (2). India officially eliminated polio in 2014. As of 2016, Nigeria, Pakistan and Afghanistan are the only remaining countries that are not polio-free (3).

Eliminating polio in India was once seen as an insurmountable challenge due to its large and mobile population, extreme poverty, and poor sanitation, among other impediments (4). The elimination of polio was considered of secondary importance to that of other diseases such as malaria, leprosy, tuberculosis, and visceral leishmaniasis (kala azar). This further hindered efforts to stop its transmission (5). Once the Indian government prioritized polio, it provoked multilateral collaboration from non-governmental organizations and public and private parties from within and beyond the country. Ultimately, in 2011, India detected its last case of polio (6).

The Strategy: Pre-2000

In 1974, the WHO launched the Expanded Programme on Immunization (EPI) with the aim of reaching all children with necessary vaccines. In 1978, the EPI was adopted by India, which accounted for at least 50% of the world's polio burden at the time (4, 7).

In 1979, the trivalent oral poliovirus vaccine (tOPV) was introduced in India (7). The tOPV protects against all three serotypes of poliovirus, and is administered orally, without the need for trained health professionals, sterile settings, or syringes (8).

Between 1978 and 1982, 104 million children were immunized with DPT (a combination vaccine against diphtheria, tetanus, and polio), and 4.1 million with three doses of tOPV. Despite these efforts, in 1981 India experienced a nationwide polio epidemic (7). From the 1970s and into the early 1990s, polio was still hyper-endemic in India, with 200 to 400,000 cases annually. In 1985, Rotary International introduced tOPV as part of its Universal Immunization Programme with the aim of reaching all Indian districts (5). Due to the low immunogenic efficacy of tOPV during the 1970s and 1980s, the number of polio cases reported in vaccinated children skyrocketed (7).

By 1988, polio was finally on the decline in India, which John and Vashishtha, in a 2013 study, attribute to increasing vaccine coverage and growing herd immunity (7). That same year, the World Health Assembly resolved to target polio for global eradication by the year 2000, a decision which India supported. The WHO promoted four strategic components to accomplish this task: achieve and maintain high OPV coverage, augment regular immunization with supplementary doses of OPV (Supplementary Immunization Activities, or SIAs), increase systematic polio surveillance with support from virology laboratories, and use local OPV campaigns to interrupt any remaining clusters of WPV transmission (7).

In 1995, the Global Polio Eradication Initiative (GPEI), together with the WHO, UNICEF, the Centers for Disease Control USA (CDC), and Rotary International, designed the National Polio Surveillance Project (NPSP), a joint initiative by the WHO and the government of India (7). NPSP supported the Indian government by providing technical assistance and monitoring for routine OPV immunization, acute flaccid paralysis (caused by polio) surveillance, and SIAs (9). At the time, roughly 50,000 individuals were still contracting polio each year in India (6).

In the same year, Pulse Polio Immunization (or PPI, formerly SIAs) was launched by the Indian government. The program consists of two annual National Immunization Days (NIDs) on which children were vaccinated at fixed booths (10). There were over 700,000 vaccination booths in each campaign, staffed by 2.5 million vaccinators (11). Approximately 172 million children received vaccinations on each NID (12). Local community mobilizers encouraged members of the community to immunize their children on NIDs, and the program was publicly supported by religious leaders and celebrities. By 1991, 53% of Indian babies had received OPV, and 73% by 1997 (5). By 1999, after nationwide PPI campaigns, WPV2 was eliminated from India, but WPV1 and WPV3 continued to circulate (10).

Post-2000

Since the objective of eradicating polio before the turn of the century was not met, efforts in India began to intensify in the year 2000. Four rounds of PPI took place nationally in the fall and winter, with two additional rounds occurring sub-nationally in eight states with low EPI coverage. In the same year, the WHO and NPSP strengthened virology laboratories to intensify virological surveillance of WPV transmission (10). WPV transmission could not be interrupted in the states Uttar Pradesh (UP) and Bihar, despite PPI campaigns reaching 94-95% of targeted children (7). As a result, PPI began house-to-house vaccinations in addition to booth immunization. By 2001, WPV transmission exclusively took place in these high-risk states (10).

To combat lack of access to tOPV, the 'under-served' strategy was launched in 2003 to target specific marginalized communities in UP, including Muslims, migrants, and other socioeconomically disadvantaged groups who were often missed in routine tOPV immunization campaigns and National Immunization Days (NIDs) (5). It became clear in 2004 that the migrant population that travelled for seasonal work needed to be prioritized, and thus the 'transit vaccination' strategy was implemented, with vaccination teams working out of bus stands, railway stations, markets, and other points of transit (7).

In 2005, the monovalent OPVs type 1 and 3 (mOPV1 and mOPV3) were licensed in India. These monovalent vaccines only confer immunity to their respective virus serotype and demonstrate increased efficacy compared to tOPV (7). Uttar Pradesh and Bihar began to use mOPV1 and mOPV3 later that year, and continued to invest in the under-served and transit vaccination strategies (13). After 2005, PPI campaigns were increased to ten times per year to compensate for low routine coverage. The quality of polio surveillance was also bolstered such that poliovirus transmission could be quickly detected anywhere in India (7).

In 2006, the inactivated poliovirus vaccine (IPV), which provides immunity against all three polio strains, was licensed in India. The India Expert Advisory Group (IEAG) began limited use of supplemental IPV dosing in Uttar Pradesh, in addition to mOPV1 and mOPV3, and focused efforts began to specifically eliminate WPV1 (7, 9).

In 2009, the IEAG announced their 107-block plan to focus on high-risk areas of Uttar Pradesh and Bihar (9). The IEAG recommended combining mOPV1 and mOPV3 to create the bivalent oral poliovirus vaccine (bOPV). By the end of 2009, WPV1 had nearly disappeared and thus WPV3 elimination was prioritized (10). In January 2010, bOPV was added to PPI campaigns. In 2010, 42 cases of WPV were detected, and in 2011, only one case was detected. In 2011, the average rate of unvaccinated children under two years old was 1.8% in Uttar Pradesh and 0.3% in Bihar (6).

Since its initiation in India in 1995, through collaboration with the government-run PPI and the WHO, the National Polio Surveillance Project provided 12.1 billion doses of OPV to India (11). In 2012, no WPV was detected and India was deemed polio-free. The WHO declared that India had successfully eliminated polio in March of 2014 (6).

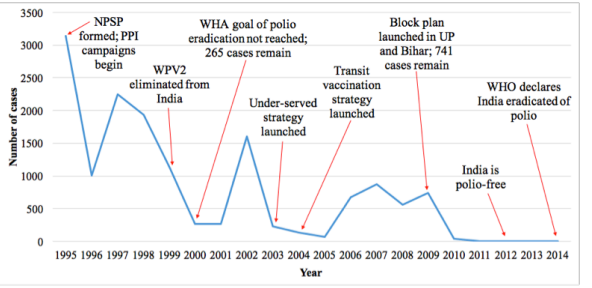

Figure 1. Total number of wild poliovirus cases in India, 1995 to 2014 (7, 14-16).

Health Impact

A study by Nandi et al. analyzed India's elimination initiative from 1982 to 2012 by calculating the variation in paralytic polio cases, polio-related deaths, and disability-adjusted life years (DALYs) (12). The authors chose 1982 as a start date for their analysis, as OPV was only introduced in India sporadically between 1978 and 1982. They created a hypothetical counterfactual model in which the polio campaign did not occur, through which

it was determined that the polio campaign prevented 3.94 million paralytic polio cases, 394,000 deaths, and 1.48 billion DALYs from 1982 to 2012.

Furthermore, as a consequence of the polio elimination campaign, improvement of routine immunization (RI) and primary healthcare have been observed in India. India's 107-block plan concentrated its efforts on upgrading RI, decreasing rheal rates, increasing breastfeeding, and improving sanitation. Encompassed in this strategy was an attempt to attack multiple issues rather than solely focusing on polio vaccination. A mass education campaign took place to spread information about the aforementioned issues, and this multifaceted approach was a contributor to the success of the eradication initiative. The campaign effected change in multiple areas of health by strengthening several programs, and ultimately enhanced routine immunization and primary healthcare while simultaneously helping to eradicate polio (17).

Financing & Cost-Effectiveness

As the possibility of worldwide polio eradication increases, the list of polio-endemic countries shrinks; polio eradication is no longer a region-specific issue, but rather a global fight. Most countries and organizations that have contributed funds to fighting polio have done so towards the global eradication effort as opposed to funding specific countries, creating difficulty in determining India-specific polio funding. Additionally, the timeline of funding is not straightforward due to the length of the polio eradication campaign. However, a general, though not absolute, understanding of the stakeholders in this initiative may be deduced from the existing literature.

Several donors have contributed specifically to India to combat polio, including the Global Alliance for Vaccines and Immunization (GAVI), Rotary International, Germany (via the GPEI), and the government of India. According to the WHO, the Indian government is one of the biggest contributors to the polio campaign. India's initiative was mostly self-funded; as of 2013 the Indian government had contributed US$2 billion towards polio elimination (18). GAVI, the public-private partnership devoted to increasing vaccination rates in developing countries, provided US$16,531,545 to India for IPV support between 2000 and 2016 (19). In addition, in 1985, Rotary International, an international service organization, introduced their PolioPlus program with the goal of immunizing all children against polio. Since its inception, PolioPlus has contributed US$176.5 million towards polio efforts in India (D. Green, December 8, 2016). Germany has provided approximately $275 to $314 million to India since 2005 (20-26).

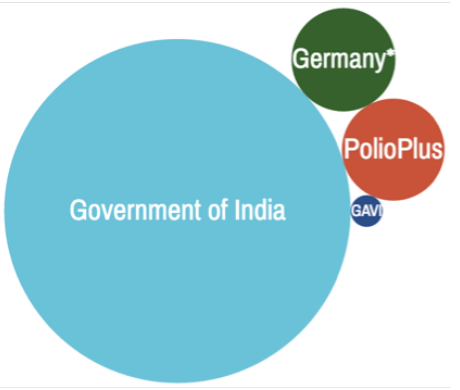

Figure 2. Approximate proportional spending by the government of India, Germany, PolioPlus, and GAVI towards polio elimination in India up to 2016.

*This is an estimated value because Germany's donations towards polio in 2007 and 2008 were split between India and Nigeria. It is not stated how much each country received from the donations. We estimated the funds were split evenly between the two countries.

Nandi et al. estimated the overall growth in productivity in India as a result of the polio campaign at US$1.71 trillion from 1982 to 2012 (12). If polio is eradicated globally, it is predicted that the net benefits will range from US$40 to 50 billion in the twenty years post-eradication, almost 85% of which will directly accrue to low-income countries (27). Although these benefits in productivity and health are profound, they must be evaluated in the context of the costs of vaccination. Prinja et al. determined the cost of vaccination for polio as US$28 per child (28).

Challenges & Reasons for Success

The GPEI accurately anticipated that India would be one of the most difficult countries in the world in which to eliminate polio. India faced several challenges such as a weak civic infrastructure for distributing vaccines, an inadequate public healthcare system, and a large mobile population prone to missing routine immunizations. In a nation with a population of more than 1.2 billion, a sizeable portion of India's inhabitants live in remote mountainous areas that are difficult to reach for vaccination. Poor sanitation and endemic diarrhea in Uttar Pradesh and Bihar, the two most populous northern states, intensified WPV transmission (10). Further exacerbating the problem, tOPV did not provide adequate immunity, leading to a rise in polio cases among already-vaccinated children throughout the late 1970s and early 1980s (7). Many communities also resisted immunization out of fear that vaccines were a covert sterilization effort from the Indian government, among other misconceptions (10). A feasible approach to elimination in India had to address each of these challenges.

Ultimately, the commitment of the Indian government toward its goal of eliminating polio was the key to success for this initiative. India's government was highly involved in the elimination process, taking ownership of the effort throughout. This included direct supervision and regular review of the GPEI program by the Prime Minister's office, as well as chief ministers taking control of elimination in their own endemic states (10).

However, the Indian government did not achieve polio elimination on its own. Collaboration between the government, non-governmental organizations, the public and private health sectors, and the general public was paramount to India's success. Organizations such as Rotary International, WHO, UNICEF, CDC USA, and the Bill and Melinda Gates Foundation contributed to the finances and labour that allowed for the realization of this enormous goal (29).

The polio elimination campaign relied on involvement of leaders from various societal spheres. Academic bodies, including the Indian Academy of Pediatrics, helped build community awareness by debunking the misconceptions surrounding polio vaccination (10). The use of religious leaders, iconic film personalities like Amitabh Bachchan, cricket players, and radio and television to support polio vaccination influenced the public to have their children immunized on NIDs (30). These combined efforts helped communicate the campaign to the public.

To address the shortage of healthcare workers needed to immunize all targeted children, the Indian government recruited more public health nurses and social workers. They also trained volunteers from all backgrounds - mothers, students, community leaders, and religious clerics - to work at vaccination booths and speak to families about upcoming immunization dates. Schoolchildren also organized and participated in large rallies to raise awareness about polio immunization (30).

There were two pervasive myths hindering the polio elimination effort. The first was the belief among certain Muslim communities that the polio vaccine was part of the Indian government's effort to sterilize Muslims again just as it had in 1975-1977 (36). The second was a misconception that a previously immunized child did not require further dosage. In fact, many parents believed that more than one dose was harmful to the child. To address the first myth, the Indian government enlisted the help of the Ulema, a council of Muslim clerics, who led public campaigns to dispel fears about sterilization. They made announcements at mosques and distributed signed letters ensuring the safety of the vaccines. To counter misinformation regarding the safety of additional vaccinations, the anti-polio campaign produced public service announcements on television educating parents as to why supplemental doses of the polio vaccine were not harmful, and were in fact essential for full immunity. The government also trained volunteer immunizers on how to persuade reluctant parents to vaccinate their children (30).

With an enormous population and lack of comprehensive health surveillance infrastructure, efficient management of the campaign was essential. Through the house-to-house strategy, for example, health workers used a house-marking system to indicate the vaccination status of each residence (30). Simple innovations, such as tracking newborns and mapping missed children, also helped facilitate widespread OPV delivery. (10).

Future Directions

Although India has eliminated wild poliovirus, the threat of vaccine-derived poliovirus (VDPV) remains. This can occur in the rare instance when the attenuated form of the virus from OPV mutates into a virulent strain. Poor sewage and contaminated water sources facilitate transmission of VDPV (31). To avoid a large VDPV outbreak, India should transition towards IPV while simultaneously strengthening its health and sewage infrastructure.

IPV, which avoids the risk of VDPV, is also more efficacious compared to OPV, though it must be injected rather than administered orally. GPEI and GAVI have been working to introduce IPV into routine immunization in India since November 2015. However, a full switch from the OPV to the IPV has not yet taken place due to shortage of supplies and difficulties with storing IPV which requires cold-chain management (32). Today, India's vaccination of infants against polio involves either a single dose of intramuscular IPV at fourteen weeks of age, or two fractional doses of intradermal IPV at six and fourteen weeks of age. Primarily as a result of cost restraints, no IPV will be given to children above this age group (A.S. Bandyopadhyay, December 10, 2016).

Furthermore, given that India shares a border with Pakistan, a nation which still has active polio cases, there is concern regarding the possible reintroduction of polio into India. The Indian government has thus mandated polio vaccine requirements for

travelers moving to and from polio-endemic countries in order to mitigate this threat (33). India continues to utilize the NPSP, a system which Dr. Nata Menabde, WHO Representative to India, claims "surpasses all quality performance indicators and standards that are recommended globally for such a system" (34). Such a program could be adapted to track the elimination of other communicable diseases, like malaria and visceral leishmaniasis.

The NPSP is the hallmark of India's current prevention strategy. It was set up by the WHO in 1997 to help support the government with early detection. As part of this large initiative, the program enrolled more than 40,000 health facilities from the private, public and informal sector to report on paralytic cases. As part of protocol, stool specimens are gathered and sent to one of eight WHO-accredited labs in the country to test for polio. Presently, this data is instrumental in identifying targeted populations to prevent future outbreaks (34). The NPSP has also expanded to monitoring for measles, Japanese Encephalitis and other immunization campaigns (35).

The challenges and successes encountered by India in this long process may serve as a guide for other countries still battling polio. By following India's example of consistent effort, supplemented with political will and international support, Nigeria, Afghanistan and Pakistan may soon eliminate polio, thus bringing the world closer to the goal of global eradication.

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Appendix

bOPV: bivalent oral poliovirus vaccine
CDC: Centers for Disease Control
DALYs: disability-adjusted life years
DPT: diphtheria, polio, and tetanus vaccine
EPI: Expanded Programme on Immunization
GAVI: Global Alliance for Vaccines and Immunization
GPEI: Global Polio Eradication Initiative
IEAG: India Expert Advisory Group
IPV: inactivated poliovirus vaccine
NIDs: National Immunization Days
NPSP: National Polio Surveillance Project
OPV: oral poliovirus vaccine
PPI: Pulse Polio Immunization
RI: routine immunization
SIA: Supplementary Immunization Activities
tOPV: trivalent oral poliovirus vaccine
UP: Uttar Pradesh
VDPV: vaccine-derived poliovirus
WHO: World Health Organization
WPV: wild poliovirus