

## CASE 7

# An Outbreak Halted in Its Tracks

## *Eliminating Polio in Haiti*

### The Case at a Glance

**HEALTH GOAL:** To eliminate circulating polioviruses and eradicate all poliovirus strains.

**STRATEGY:** School- and community-based polio vaccination for children under age 10 via National Immunization Days and house-to-house campaigns.

**HEALTH IMPACT:** Outbreak stopped. Last case of paralytic polio in Haiti in 2001.

**WHY IT WORKED:** Swift action after first case of paralytic polio was identified. Coordination between Haiti, the Dominican Republic, and international donors. Improved surveillance and monitoring.

**FINANCING:** US\$4.82 million.

**SCALE:** More than 90 percent of 2.5 million Haitian children under age 10.

Polio is a highly infectious virus whose best-known lasting effect is paralysis, often of the legs and lower body. The virus attacks the motor neurons of the spinal cord and brain stem. A person who contracts paralytic polio will feel tired, stiff, and in pain; will have trouble breathing; and may experience muscle spasms. More acute muscle pain, loss of reflexes, and sudden paralysis can follow. These symptoms may be temporary or cause permanent disability, requiring a person to use a wheelchair or crutches, or in the most severe cases, may end in death. There is no cure for polio, and in many affected countries there are few supportive therapies to treat its symptoms and prevent further health complications.

When an individual is confirmed to be suffering from paralytic polio, he or she is seen as the “tip of an epidemic iceberg.”<sup>1</sup> Without proper vaccine coverage and surveillance, one case of polio can escalate quickly into an epidemic. Ridding the world of polio is an ongoing struggle. Some countries have seen polio return after being designated polio-free for many years.

This was the case in 2000 in Haiti, when a two-year-old girl in Haiti’s Northwest Department contracted paralytic polio from a circulating vaccine-derived strain of the virus. Largely due to poor sanitation, limited vaccine cov-

erage, and weak surveillance, the outbreak caused 20 more cases across Hispaniola, a Caribbean island shared by Haiti and the Dominican Republic, over the next year.<sup>2</sup>

Haiti’s broader political and health system challenges added to the perilous mix of risks that opened the door to polio.<sup>3</sup> Ongoing political instability is one reason Haiti was, and remains, the poorest country in the western hemisphere—in 2001, 55 percent of the population lived on less than US\$1 per day.<sup>4</sup> This level of extreme poverty was a lasting effect of the traumas of the 1990s, when Haitians faced serious violations of their human rights, poverty, malnutrition, and unstable institutions as the country struggled to establish democracy and the rule of law.

The outbreak might have been worse. Despite the adverse political environment and the government’s small contribution to the health sector—only 1–2 percent of the gross domestic product—the Ministry of Public Health and Population and international agencies such as the Pan American Health Organization (PAHO) and the US Centers for Disease Control and Prevention (CDC) quickly invoked aggressive control measures and cut off circulation of the virus when polio broke out.<sup>5</sup> Although vaccination coverage rates fluctuated between

2001 and 2013, immunization against polio has largely been sustained.<sup>6</sup> Haiti managed to stave off yet another polio outbreak after an earthquake in 2010, when some feared the disease might reemerge alongside a tragic cholera outbreak.<sup>7</sup>

Around the globe, polio is nearing elimination. In August 2015, the entire continent of Africa marked one year without a case of wild polio. But countries remain at risk of outbreaks for an extended period after the apparent elimination of the disease, especially where surveillance systems are weak. Haiti's experience in combating a resurgent outbreak of polio serves as a cautionary and inspiring story of how an extremely poor country with limited human resources can do basic public health right.

### The Toll of Poliomyelitis

Commonly known as polio, poliomyelitis is caused by polioviruses, which can emerge in a “wild” or natural form or, in some cases, as a result of a mutation of the live version of the virus that is used in the oral polio vaccine. Although the majority of people who contract polio do not exhibit symptoms, others experience flu-like signs, including fever, sore throat, nausea, or headache.<sup>8</sup> And in the least common yet most extreme scenario, polio invades the central nervous system, affecting the brain and spinal cord and causing paralysis.

The disease is commonly spread by an infected person's feces; the insidious virus can spread both before and after symptoms appear.<sup>9</sup> Ninety percent of infected people don't exhibit symptoms, but they still have the ability to infect others. Even worse, the virus remains viable outside the body for up to two months, surviving in water, food, feces, and even clothing, where it can easily infect others through contact. Young children with low resistance to the virus, especially in places with poor sanitation, are at particularly high risk for infection.

Polio can be prevented with a vaccine, which comes in two forms, an injection and an oral vaccine. The injected polio vaccine (IPV) is made from a version of the poliovirus that has been deactivated; it provides immunity after four shots and is the standard in high-income countries.<sup>10</sup> The oral polio vaccine (OPV), developed by Dr. Albert Sabin, is made from a weakened but still active strain of the poliovirus and requires at least three doses for immunity.<sup>11</sup> OPV is cheaper than IPV, but OPV provides intestinal immunity and was the vaccine of choice in the Americas to eradicate wild poliovirus. Like other vac-

cines, both IPV and OPV work by activating an immune response in the body so that the body builds up antibodies to protect itself from the virus.

Thanks to these vaccines, the world has seen a dramatic reduction in polio cases from an estimated 350,000 cases in 1988 to an all-time low of just about 100 cases in 2015.<sup>12</sup> Most of the 126 countries where polio was formerly endemic had succeeded in eliminating polio by 2001.<sup>13</sup>

Ironically, however, this success has come with a specific risk: the widely used OPV can cause polio, threatening communities that have low immunity and poor vaccine coverage. This occurs because the active form of the virus in OPV can replicate in the intestines, be excreted when people defecate, and spread around a community. Although this can be beneficial because the excreted virus can help others build up their immune responses to the virus (known as passive or herd immunity), it can also be dangerous, posing the risk of creating a type of polio known as circulating vaccine-derived poliovirus (cVDPV). This type of virus can circulate for longer than a year and can mutate into a form that acts like a wild virus, easily transmitting to people who are not immune and potentially paralyzing them.<sup>14</sup>

In Latin America in the 1970s, there were an estimated 15,000 paralysis cases and 1,750 deaths from polio every year. Following the successful eradication of polio in the United States, PAHO began a polio eradication campaign in the 1970s in Latin America and the Caribbean. In 1977, countries in the region added OPV to PAHO's Expanded Program on Immunization (EPI) schedule to combat wild poliovirus.

The plan for eliminating wild poliovirus across North, Central, and South America had been realized under the leadership of Dr. Ciro de Quadros, director of the immunization program at PAHO. De Quadros found his inspiration in the successful control programs in Brazil and Cuba, which, in 1963, was the first country in the region to successfully eradicate wild poliovirus.<sup>15</sup> De Quadros enlisted the help of Rotary International, the United States Agency for International Development (USAID), the United Nations Children's Fund (UNICEF), the Inter-American Development Bank, and the Canadian Public Health Association to launch widespread OPV immunization campaigns. The campaigns and robust country surveillance systems proved successful, and polio's spread was curtailed.<sup>16</sup> The last case of paralytic polio was documented in Peru in 1991.<sup>17</sup> After maintaining zero polio cases for three years, the World Health Organization (WHO)-designated

Region of the Americas was officially certified polio-free in 1994. The region thought it had seen the end of polio.

### **Putting an Idea in Motion: Haiti's Surveillance System Sounds the Alarm**

Haiti's health system was on particularly shaky ground following a violent coup d'état in 1991. President Jean-Bertrand Aristide, the first democratically elected president in Haiti, was overthrown and forced into exile, and the military proceeded to violate citizens' human rights. The turmoil led donor countries and multilateral agencies to suspend their support and technical aid to the Haitian Ministry of Public Health and Population's programs.<sup>18</sup>

Haiti's weak health system degraded further under these conditions. Extremely low polio vaccine coverage, alongside poor sanitation conditions, continued to plague the country throughout the 1990s.<sup>19</sup> Shortly after the region was deemed polio-free, the Haitian government suspended concentrated mass immunizations that took place on National Immunization Days.<sup>20</sup> These OPV immunization campaigns were a tried-and-true strategy for fighting the virus, but interest in and financing for them had faded in Haiti after the wild poliovirus had been wiped out.<sup>21</sup> The result was devastating: the share of children under one year old receiving at least three doses of OPV stagnated at 30–50 percent during the 1990s.<sup>22</sup> Haiti's staggering debt obligations also contributed to health system weaknesses; domestic funding for basic sanitation and public health interventions was simply cut.<sup>23</sup>

A lack of investment in water quality measures and sanitation also created conditions conducive to a polio outbreak. The political climate contributed to these conditions; corrupt officials and violence against ordinary citizens got in the way of much-needed rural water and sanitation improvement projects over several decades. This was particularly troubling because vaccine-derived poliovirus can live in water and be transmitted via feces.<sup>24</sup>

Despite these challenges, there was one piece of good news: Haiti's epidemiological surveillance system (ESS) had remained more or less intact. This was thanks in large part to the Haitian Children's Institute (Institut Haïtien de l'Enfance), a private group that conducts national health surveys.

In Haiti, the last case of paralytic polio had been documented by the ESS in 1989.<sup>25</sup> However, in the summer of 2000, a two-year-old girl in the country's Northwest Department experienced acute flaccid paralysis (AFP), a

sudden onset of paralysis, and the case was reported by the ESS. A follow-up investigation by Haiti's Ministry of Public Health and Population, PAHO's Caribbean Epidemiology Center, and the CDC confirmed the worst fears: polio was back.<sup>26</sup> Shortly after that, another case of AFP was confirmed as poliomyelitis across the border in the Dominican Republic.

It was the ESS routine surveillance system that detected the initial new case in 2000. Per ESS requirements, the case was investigated as suspected poliomyelitis. A stool sample was sent to a laboratory within the region—PAHO's poliovirus laboratory at the Caribbean Epidemiology Center—and the poliovirus was isolated.<sup>27</sup> The isolate was then sent to the CDC poliovirus laboratory for further investigation and confirmation of the findings.<sup>28</sup>

Following the CDC's confirmation, Haitian health officials learned they were dealing with a poliovirus that was derived from the vaccine, one that was biologically similar to the wild poliovirus. In other words, a vaccine-derived virus had developed the ability to behave like its naturally occurring cousin, causing paralysis and rapid person-to-person transmission.<sup>29</sup> It seemed likely that the virus had already infected thousands more who may have been contagious but had not exhibited symptoms. It was not long before several more cases of paralytic polio were confirmed on Hispaniola; by early 2001, 8 cases had been confirmed in Haiti and 14 in the Dominican Republic.<sup>30</sup>

The lab analysis traced the source of this particular strain to an OPV dose given to a child in a community with low vaccine coverage in late 1998 or early 1999.<sup>31</sup> Epidemiologists concluded that the outbreak first began among nonimmune children in Haiti and spread to the Dominican Republic a few months later via contaminated food or an infected person.<sup>32</sup>

The confirmed cases were all in children ages 2 to 12 who were either entirely or partially unvaccinated and mostly living in areas with partial OPV coverage.<sup>33</sup> In the Northwest Department, the site of the first case, vaccination coverage was only 40 percent as of 2001.<sup>34</sup>

### **Polio Vaccination in Action**

PAHO and the CDC jumped in to help Haiti stop polio in its tracks. The two agencies sent 16 epidemiologists to conduct an active search for AFP cases in both countries.<sup>35</sup> They reached out to religious leaders, teachers,

day care center directors, mothers, and traditional healers to locate unreported cases of AFP.<sup>36</sup>

Meanwhile, the government of Haiti put aggressive control measures back in place. Initial action included vaccination near the site where paralytic polio had been detected, plus vaccination nationwide at fixed posts such as at health facilities. In early 2001, the Ministry of Public Health and Population, with the technical help of PAHO, conducted two rounds of vaccination. But inadequate planning, logistical problems, and heavy rains undermined the government's early control activities, and immunization reached barely 40 percent of the 1.2 million Haitian children under the age of five.<sup>37</sup> By mid-2001, Haiti was in trouble—the government and its partners had not managed to immunize enough of the population to guarantee protection.

This prompted the minister of health, Dr. Jean Claude Voltaire, to launch a new strategy that was even more ambitious: nationwide school-based vaccination of all children under 10 followed by two rounds of house-to-house OPV vaccination of all remaining eligible children. By this point the international response had also intensified. PAHO, UNICEF, the World Bank, the Canadian government, and USAID provided technical and financial support to the Health and Education Ministries for the new strategy. The intensified efforts led to two national immunization campaigns in the spring and fall of 2001.

Sensitive and timely reporting of AFP had proved to be critical for controlling polio. The ESS was key in the detection of and response to the outbreak, yet the surveillance system had weak links. At the time of the outbreak, more than half of the paralysis notification sites had not been completing their weekly reports, and not one AFP case reported over the previous five years had stool specimens collected and tested.<sup>38</sup> To improve surveillance, more than 100 local healthcare workers were trained to conduct active case searches during their community-based activities.<sup>39</sup> PAHO also continued to send epidemiologists to reinforce surveillance activities, and the Ministry of Public Health and Population even offered a reward of US\$100 to anyone who reported a laboratory-confirmed case.<sup>40</sup>

The government of Haiti coordinated its efforts with the government of the Dominican Republic, sharing information across the border. By late 2001, coordination had turned into collaboration. Senior health officials from the two countries' ministries of public health met at the main border area to devise a plan for ensuring that all

children passing through the official border crossings were vaccinated at one of the specially placed vaccine posts on either side.<sup>41</sup>

The measles vaccine program in both countries had been put on hold when paralytic polio arose. However, children needed protection from both deadly epidemics, and experts determined that a joint polio and measles campaign would be both efficient and effective. By mid-2001, the first ladies of both countries were working with health ministers, government authorities, nongovernmental organizations, and international agencies to inaugurate a combined measles-polio campaign.<sup>42</sup> Both vaccines were administered when the third national OPV immunization campaign took place the following year.

The success of the immunization campaigns and surveillance activities were hard won, as Haiti's Ministry of Public Health and Population had to overcome significant logistical problems. Gaining access to Haiti's poorest, most vulnerable areas was a particular challenge. Most of the country's roads were in terrible condition, and half of the country's health centers lacked adequate cold-chain equipment such as refrigerators to keep OPV viable. Some vaccine vials spoiled or broke, and some vaccination activities had to be rescheduled.<sup>43</sup>

### **The Payoff: Polio Eliminated, Again**

Haiti's immunization campaigns effectively controlled the polio outbreak by blanketing the country with protection. The Expanded Program on Immunization (EPI) in the Americas reported that 2.4 million OPV doses were administered to children during the first National Immunization Day and house-to-house mop-up, reaching 88 percent of children under age 10.<sup>44</sup> The second campaign did even better, reaching 93 percent of the target population.<sup>45</sup> Local monitoring reports from healthcare workers on polio vaccine coverage and suspected AFP cases were used to validate the administrative data reported by the EPI. This confirmed approximately 90 percent immunization coverage, and mop-up activities bumped that percentage even higher.<sup>46</sup>

At a meeting in August 2001, one year after the first confirmed case of paralytic polio, George A.O. Alleyne, the director of PAHO, called Haiti's polio campaign a "success story."<sup>47</sup> In fact, a case of paralytic polio that had been diagnosed on April 26, 2001, in a two-year-old in Port-au-Prince turned out to be the last documented case in Haiti.<sup>48</sup> The Dominican Republic also put a stop to the

circulating vaccine-derived virus. A case there in January 2001 was later confirmed as the last.<sup>49</sup>

No new cases of paralytic polio were reported after the immunization campaigns, confirming their success. It is generally recognized that routine immunization prevents and stops polio outbreaks; without it, immunization coverage drops, levels of immunity decline, and wild or vaccine-derived poliovirus can find fertile ground. Still, it remains unclear which aspects of Haiti's efforts were the most effective and efficient, and how big an impact the campaigns had (see Box 1).

### Gains at What Price?

Stopping the vaccine-derived paralytic poliovirus outbreak cost Haiti and its partners a total of US\$4.82 million, according to the EPI.<sup>50</sup> Of that, Haiti's Ministry of Public Health and Population, despite its limited budget, managed to contribute 20 percent—about 2 percent of its total public health expenditure in 2001—to the effort.<sup>51</sup> Partners contributed the rest: the Canadian International Development Agency, PAHO, the World Bank, the WHO, Rotary International, UNICEF, and USAID.<sup>52</sup> UNICEF's role was of particular importance, as the organization paid for the vaccines and for cold chain equipment to keep vaccines viable when transported and stored.

Modeling the cost-effectiveness of combating an outbreak like polio is inherently difficult given the significant uncertainty around how and where an outbreak will spread. Quantifying costs due to a “societal reaction” such as anxiety or violence is also difficult.<sup>53</sup> Furthermore, given the lack of an attributable estimate of health impact, it is a challenge to estimate the cost-effectiveness of the polio eradication efforts in Haiti. However, it is clear that a large value is placed on the eradication of polio through the mobilization of the government and international partners. Haiti and external donors demonstrated this by the large sums they have invested in eliminating polio.

Notwithstanding methodological challenges, cost-benefit analyses of global polio eradication have been undertaken because eradication will have numerous long-term social benefits and is generally perceived as a global public good.<sup>54</sup> The Global Polio Eradication Initiative (GPEI) estimates that eradicating polio at the global level will cost US\$5.5 billion from 2013 to 2018.<sup>55</sup> That's a lofty estimate—but failing to achieve global eradication would likely cost much more in terms of longer-term treatment

### Box 1. Strength of the Evidence

Haiti's efforts to control the polio outbreak appear to be a success: the country has not seen a case since 2001. However, only an impact evaluation could demonstrate that the country controlled the outbreak using the most effective tactics.

Another challenge in attributing impact to Haiti's ramped-up activities is confirming the actual coverage—the reported immunization data are based on the number of doses administered and the estimated target population, which can be inaccurate. In fact, in some cases the coverage rate was reported to exceed 100 percent because data were simply divided by the estimated target population, which was based on out-of-date census data. For instance, in mid-2001, it was reported that 2.4 million doses of OPV had been administered to an estimated 2.26 million children. This method of assessing coverage depends heavily on strong local record keeping to feed vital statistics systems and accurate population estimates, both of which are challenging in low-resource countries like Haiti.

costs. Eradicating polio by 2018 would result in massive savings, with some estimates showing a savings of US\$40 billion to US\$50 billion by 2035, and most of those savings would be in the world's poorest countries.<sup>56</sup>

### The Keys to Lasting Success

Haiti's polio success can be attributed to several factors: a quick response from the government and international agencies, the government's commitment to controlling polio, sustained and then improved surveillance, and effective coordination with the neighboring government of the Dominican Republic and other partners.

Although the immunization program and surveillance system failed to provide an early warning of the circulating vaccine-derived polio outbreak in Hispaniola, Haiti stepped up to the plate and deployed its vaccination program and screening capabilities after a case was discovered. Notably, the more rigorous activities Haiti undertook following the disappointment of the initial attempt followed international good practice—the model for polio control that had proved the importance of vaccine coverage and sensitive surveillance decades earlier. In the

1970s and 1980s, the success of polio eradication programs was based mainly on three strategies: National Immunization Days, house-to-house mop-up campaigns in the vicinity of every new outbreak and in areas that were hard to reach, and surveillance using a system that included analysis and diagnosis in virology labs.<sup>57</sup> These lessons from history proved hard to ignore.

Although Haiti's finances were in dire straits, its renewed political commitment to eliminating polio was commendable. The Ministry of Public Health and Population's funding of one-fifth of the polio control program demonstrated that the government was serious about cutting off the polio epidemic quickly. The most visible sign of government commitment was health minister Voltaire's and first lady Mildred Trouillot Aristide's leadership on the combined polio-measles campaign.

Haiti's Ministry of Public Health and Population could not have halted the outbreak on its own. Bilateral and multilateral aid agencies and foreign governments mounted a robust and sustained response to the need to detect cases of paralytic polio. Their financial support and technical expertise were indispensable. Coordination and cooperation between the governments of Haiti and the Dominican Republic led to meetings to ensure that the two countries' efforts were in sync, especially at the border, which proved to be essential.

The underlying causes of Haiti's polio outbreak—a weak health system and struggling sanitation efforts—still persist. Thus, Haitians must remain vigilant to ensure that another epidemic of the vaccine-derived virus does not occur. National reform of the water and sanitation sector was not voted into law until 2009, and the devastating earthquake of 2010 derailed long-term infrastructure plans in favor of pressing humanitarian needs.<sup>58</sup> Efforts to reduce the risk of another outbreak rely on the government's ability not only to ensure polio vaccination coverage but also to build up capacity for water and sanitation improvements and hygiene education to ensure that a vaccine-derived poliovirus does not spread from feces to water or food (see also chapters 20 and 22 on sanitation programs in Indonesia and Peru, respectively).

### Implications for Global Health

The GPEI, launched in 1988, has led the way toward an astounding 99 percent reduction in polio incidence worldwide. Still, wild and vaccine-derived polioviruses

remain threats in a few strongholds, notably in the populous and complex nations of Pakistan and Afghanistan.

Polio's ability to cross borders underscores the urgency of closing the gaps in immunity and bringing an end to polio. Whereas the outbreak on Hispaniola was restricted to two countries that share one island, the circulation of wild and vaccine-derived polioviruses in Nigeria spread to 20 countries across Africa, the Middle East, and Southeast Asia between 2003 and 2008 (see Box 2).<sup>59</sup> But polio elimination programs face budget shortfalls, and it has become increasingly difficult to maintain high levels of vaccine coverage in countries that have been certified polio-free.<sup>60</sup> Some governments are asking why so much money is needed for such a small number of cases,<sup>61</sup> and “donor fatigue” remains a threat to polio funding.<sup>62</sup>

Furthermore, there is some debate about the best strategies for polio control. Some claim that polio vaccination campaigns now deliver fewer returns than they did when the burden of disease was higher, and that those resources may be better spent, for example, on water and sanitation infrastructure.<sup>63</sup> However, national immunization days remain a proven tool. Take more recent polio breakouts in India and Nigeria, where canceling some or all routine national immunization days resulted in a jump in polio cases and likely set both countries back millions of dollars. And when India brought back national immunization days several years later, the polio epidemic subsided. Time and again countries have seen this trend reoccur, fostering a widespread acceptance of routine national immunization days as a critical tactic to curb the spread of the poliovirus.

To achieve global eradication, the leaders of the GPEI—the WHO, Rotary International, the CDC, UNICEF, and the Bill & Melinda Gates Foundation—and affected-country governments need to agree upon an endgame strategy. This will inevitably require the elimination of the oral vaccine to prevent a vaccine-derived polio outbreak.

There are two potential strategies for eliminating the use of OPV. The first is a transition from OPV to IPV. However, there are questions about the efficacy of IPV in preventing poliovirus circulation in the highest-risk settings: IPV provides less protection than OPV to unimmunized people because IPV does not create herd immunity.<sup>64</sup> IPV is also more expensive, which could be a challenge in low- and middle-income countries if the vaccine costs are not incorporated into current vaccination programs.<sup>65</sup> Still, IPV would reduce the risk of having to pay to respond to a vaccine-derived outbreak caused by OPV.<sup>66</sup> The second strategy is a carefully coordinated termina-

tion of OPV without replacing it with IPV. However, this could cause new outbreaks of vaccine-derived virus if not coordinated on a global scale.<sup>67</sup>

An alternative option is to continue to rely on OPV to keep the disease under tight control. Yet as the case of Haiti demonstrates, using OPV indefinitely could be lethal if not coupled with sensitive surveillance, maintenance of vaccine stockpiles, and investments in eradicating polio's underlying causes such as contaminated water and poor sanitation. Most health economists and advocacy groups argue that a carefully planned strategy for worldwide cessation of OPV use should be implemented.<sup>68</sup> Some have also argued that there is an ethical imperative to eradicate polio when the world has the means to do so, and that it would cost less to eradicate the virus than to control it.<sup>69</sup>

Although the GPEI deadline for eradicating polio has been pushed from 2000 to 2007 to 2018, achieving this goal is still feasible. The essential ingredients—broad population immunity and sensitive surveillance systems—are almost within reach. Some even say the world has never been closer to eradication, despite the number of polio cases in Pakistan and Afghanistan.<sup>70</sup> The resurgence of polio in Haiti remains a prime example of what can happen if a country scales back its vaccine campaigns.

The need for rapid responses to health emergencies is only increasing. As the Ebola outbreak of 2014 confirmed, without international preparedness and vigilance, a small disease outbreak can quickly spin out of control, with massive health and economic implications throughout a region. Haiti's experience shows that regional crises can be prevented with smart partnerships among neighboring governments and international health and aid agencies. Having the WHO, CDC, PAHO, UNICEF, and others at the ready was essential to preventing paralytic polio from spreading further on the island of Hispaniola and beyond.

But a focus on eradicating polioviruses via vaccines is not enough. The continued neglect of water and sanitation improvements remains troubling; Haiti's cholera outbreak in 2010 shows that Haitians remain highly vulnerable to waterborne health threats. Without effective investments in water and sanitation, public health authorities must remain doubly vigilant. And international partners should consider the merits of investing in significant water and sanitation improvements in the near term, rather than continuously having to respond to emergency funding requests for vaccination programs over the long term.

## Box 2. Achieving Polio-Free Status in Nigeria<sup>71</sup>

Nigeria, despite nearly 30 years of polio eradication efforts, experienced 801 cases of wild poliovirus in 2008—the most of any country that year.<sup>72</sup> Challenges to eliminating polio abounded: geographic diversity, poor infrastructure, tensions between the Muslim north and the Christian south, and a lingering mistrust of biomedicine.

But new leadership of Nigeria's National Primary Health Care Development Agency in 2008 revived the country's commitment to managing polio. Based on learnings from Nigeria's previous polio strategies, the Ministry of Health undertook an ambitious new campaign targeting 160 million people in 36 states. The campaign was funded by the WHO, Rotary International, the CDC, UNICEF, and the Bill & Melinda Gates Foundation.

To improve accountability, the Ministry of Health established an Emergency Operations Center (EOC) to oversee the campaign and to ensure that all key international and national players—especially state governments—were

doing their job to improve vaccination coverage. The campaign strategy also included working with traditional leaders to gain community buy-in, increasing the number and efficiency of community vaccinators, and implementing geographic information system technology to identify vaccine coverage shortcomings.

The efforts proved successful: the last case of wild poliovirus occurred in 2014, and the WHO announced that Nigeria was polio-free in September 2015. Between 2014 and 2018, the campaign is expected to avert between 30,000 and 35,000 deaths and save US\$4 billion.<sup>73</sup> The mechanisms created by the campaign, such as the EOC, also helped halt an incursion of Ebola in 2015.

Nigeria's experience offers lessons for countries still fighting polio: develop a context-specific strategy; improve accountability; establish community trust; and implement frequent, independent monitoring.

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