

# Acute Flaccid Paralysis surveillance in polio eradication and beyond: Learning from Bangladesh

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## Research Article

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# Abstract

**Background:** The Global Polio Eradication Initiative (GPEI) helped to develop the standard acute flaccid paralysis surveillance (AFP) system worldwide which comprises infrastructure, knowledge, expertise, funding, technical assistance, and trained personnel. AFP surveillance can complement any disease surveillance system, and many countries, including Bangladesh, are now utilizing these polio surveillance assets for monitoring other vaccine-preventable diseases. This paper outlines how AFP surveillance has evolved in Bangladesh over time, its success and challenging factors, and its potential to facilitate other health goals.

**Methodology:** This mixed-method study includes a grey literature review, a survey barriers and facilitators, and key informant interviews (KIIs) to gather relevant in-depth information on AFP surveillance in Bangladesh. Grey literature was collected online and via paper documentation from GPEI stakeholders. Online and in-person surveys were conducted in six divisions of Bangladesh, including Dhaka, Rajshahi, Rangpur, Chittagong, Sylhet, and Khulna, to map tacit knowledge ideas, approaches, and experiences. KIIs were conducted at national, and sub-national levels. Data were then combined on focused emerging themes including history, challenges, and successes of the AFP surveillance system in Bangladesh.

**Results:** AFP surveillance in Bangladesh was first introduced in 1990 at the district and Upazila level major hospitals. High population growth, low performance, hard-to-reach areas, and groups of people residing in risky zones were significant challenges to implementing this surveillance system. Surveillance was gradually enriched by establishing certification standards and community-based AFP surveillance and improved Surveillance Immunization Medical Officer (SIMO) network activities, laboratory activities, and proper monitoring and evaluation. In Bangladesh, a national disease surveillance system and a laboratory are now being used for multiple diseases, including polio, measles, Japanese Encephalitis, neonatal tetanus, etc.

**Conclusion:** In Bangladesh, it is evident that the AFP surveillance system is supporting the health system more broadly by building knowledge, experience, and assets and forming a solid platform for other health programs. In addition, its strengths can be leveraged for combating new and emerging diseases. However, the sustainability of the AFP surveillance in Bangladesh still needs collaborative support from partners, mainly in the form of technical assistance.

## Background

At the 41st World Health Assembly (WHA) held in 1988, 166 Member States agreed to a landmark resolution to constitute a Global Polio Eradication Initiative (GPEI) to eradicate poliomyelitis, a potentially fatal infectious disease caused by three viral serotypes [1]. The World Health Organization (WHO), in collaboration with Rotary International, the US Centers for Disease Control and Prevention (CDC), the United Nations Children's Fund (UNICEF), and Global Alliance for Vaccine Initiative [2], became the GPEI core group and established a goal of polio eradication the year 2000 [3]. One of the critical strategies for

eradicating wild poliomyelitis was establishing a unique surveillance system in every country to detect all Acute Flaccid Paralysis (AFP) cases in children in the community. The strategy also aimed to confirm the presence or absence of wild poliovirus in dedicated reference laboratories by following a standard WHO protocol [4].

AFP is defined as the sudden onset of weakness or paralysis of limbs often associated with fever in children less than fifteen years of age. This sensitive case definition can capture acute poliomyelitis and other diseases with a similar clinical manifestation such as Guillain-Barre syndrome (GBS), transverse myelitis, traumatic neuritis meningitis, encephalitis, and brain tumours [5]. AFP surveillance system identifies recent-onset flaccid paralysis detection among children through two approaches: passive (reports received from healthcare providers) and active surveillance (active search conducted by sensitized surveillance teams). AFP surveillance quality depends on early detection and reporting, quality of stool specimen collection and cold chain, prompt transportation of stool specimen to the laboratory, and timely reporting of results [5, 6]. Despite the massive decline in worldwide polio cases, two countries - Afghanistan and Pakistan - have yet to eradicate Polio. According to WHO, the circulating vaccine-derived poliovirus type-2 (cVDPV2) cases are spreading rapidly, and the number in 2020 was 1,009 which is, 254% higher than the number of 2019 [7]. Therefore, it is essential to continue surveillance to achieve global eradication.

The success and lessons learned from the AFP surveillance system can complement other surveillance activities to detect disease outbreaks in the community [4]. Many countries are now using GPEI assets, including the AFP surveillance system, to monitor other vaccine-preventable diseases including measles, rubella, and meningitis [8, 9]. Similarly, after the onset of the COVID 19 pandemic, Uganda, Nigeria, Afghanistan AFP surveillance teams have been deployed to identify active case searches for COVID-19 [10].

Bangladesh has also adopted a polio eradication goal since 1995 and has implemented four basic strategies following WHO's suggestion, including i) Routine immunization, ii) Supplementary immunization activities (SIAs), iii) AFP surveillance, and iv) Mop-up campaigns [11, 12]. The country achieved polio-free status on March 27, 2014, and has since successfully maintained all the key performance indicators for AFP surveillance over the past ten years [11]. Bangladesh has also integrated surveillance of measles-rubella, Neonatal Tetanus (NNT), Japanese Encephalitis (JE), Adverse effects following Immunization (AEFI), and other Vaccine-Preventable Disease (VPD)s into the AFP surveillance [13]. An evaluation of the AFP surveillance system showed that the system correctly identified children with polio and non-polio diseases like GBS and guided mop-up campaigns to raise awareness and promote polio vaccination [11]. The AFP surveillance team in Bangladesh has also been serving as frontline health workers in every district for COVID-19 response since the pandemic started [14].

This paper describes the evolution, challenges and contributing factors to the implementation of AFP surveillance in Bangladesh. It highlights implementation strategies and key considerations needed for

establishing disease surveillance systems in Bangladesh and similar low- and middle-income countries and describes how AFP surveillance is being repurposed to support other disease control programs.

## Methods

This study is a part of the, "Synthesis and Translation of Research and Innovations from Polio Eradication" (STRIPE) project which is a consortium of seven international academic partners, including the James P Grant School of Public Health, BRAC University, Dhaka, Bangladesh and is led by the Johns Hopkins Bloomberg School of Public Health (JHSPH) [15].

In this study, a sequential explanatory mixed-method study design (Fig. 1) was used to map, synthesize, and disseminate lessons learned from the global polio eradication effort in Bangladesh [16].

The first step of the study was a grey literature review. The data collected through the grey literature review was used to develop the questionnaire for the survey, which was followed by Key informant interviews (KII).

A grey literature review was conducted to prepare the conceptual basis or foundation of the study. Literature was prioritized from a select number of published citations and references regarding GPEI in Bangladesh. Necessary permission from the Government of Bangladesh was obtained for conducting both online and offline searches for reports, standard operating procedures (SOPs), strategy documents, presentations, policies, and other documentation related to polio eradication in Bangladesh. Websites of GoB and related organizations such as Rotary International, UNICEF, BMGF, the WHO, GAVI, and icddr,b were explored, and relevant information was downloaded. Hard copies of unpublished grey documents were searched in the repositories of the Expanded Program of Immunization (EPI), Directorate General of Health Services (DGHS), GoB. Documents were also collected from the WHO Bangladesh office and other individuals related to polio eradication initiatives in Bangladesh.

Screening of documents was conducted by two independent reviewers. Relevant documents that addressed GPEI support in Bangladesh, post-polio effects for GPEI roll-out/effects in Bangladesh, included vaccine OPV/IPV, included polio related fieldwork in Bangladesh or lab work undertaken by GPEI partners, included wild poliovirus and vaccine-derived polio studies, and polio surveillance were included. The documents in the Bangla language were translated into English. Data extracted from the documents were transferred into Qualtrics © (online survey software) and analyzed under different GPEI strategies, including setting up and mobilization, implementation, end game strategies, global health on polio eradication, and impact on other health programs and health systems, including, key enablers/facilitators and barriers to the implementation of the surveillance of polio program.

The quantitative survey was conducted with the members of Bangladesh's "Polio Universe". The polio universe was created by identifying individuals who were directly involved in implementing polio eradication activities in Bangladesh for a minimum of 12 or more months between 1988 and 2019. Personal references and email addresses of the listed persons were collected from the EPI database.

Some respondents were also identified through snowball sampling. This quantitative survey was a part of a global survey, built-in Qualtrics © and circulated via email through a web link. The questionnaire was designed based on the Consolidated Framework for Implementation Research (CFIR) and the socio-ecological model embracing the internal and external contexts for implementation, program barriers, and enablers to surveillance [15]. The survey was also used to identify potential participants for KII. The survey tool was pretested and modified according to the Bangladesh context. The survey was sent to the polio universe members in six administrative divisions of Bangladesh (i.e., Chittagong, Dhaka, Khulna, Rajshahi, Rangpur, and Sylhet Divisions). In general, the responses to the online survey were not satisfactory, except for the national level participants. After discussing with the Johns Hopkins team, the survey for sub-national participants was made paper-based instead of online due to a number of challenges like poor internet connectivity and lack of knowledge of the participants to use online platforms. The surveys taken in the local language were translated into English, and data were cleaned. Quantitative data were analyzed in Stata 13, and qualitative free responses were coded and analyzed according to themes like contextual factors, implementation strategies, barriers, and strategies adopted to overcome these barriers.

KIIs were conducted following the survey. Relevant information related specifically to AFP surveillance in Bangladesh was extracted.

Eighteen KIIs were conducted with a subset of the polio universe who had extensive experience in working in polio eradication efforts in Bangladesh. The participants were identified from the survey data considering their experience and expertise in polio eradication activities and also included persons who were nominated by several survey respondents as KII participants. The KIIs were conducted by two trained interviewers with prior expertise in qualitative research methodology. Informed written consent was taken from each participant. Interviews were recorded by using an audio recorder, and field notes were also taken. The interviews were transcribed and translated into English by expert transcribers and translators of BRAC JGPSP and also checked for any error by the interviewers.

The analysis plan for KII data focused on identifying emerging themes on the evolution of the AFP surveillance system set up and organization, critical activities, and strategies adopted for stakeholders' support, challenges and successes, and the role of surveillance beyond polio eradication in Bangladesh.

The quantitative and qualitative data were then mixed. The survey data was utilized to describe the frequency of enablers and challenges to surveillance of polio program and the KII data was used to explain how the surveillance is organized, works and also to describe more about the enablers and barriers in different contexts. The literature review was also used to complement the findings generated from the survey and KII data.

**Ethical approval** of this study was obtained from the Institutional Review Board of BRAC James P. Grant School of Public Health, BRAC University.

## Results

92 documents were identified following the search criteria, and 23 were excluded due to insufficient and repeated information. The remaining 69 documents, including bulletins, reports, fact sheets, scientific papers, manuals, newspapers, PowerPoint presentations, and other grey literature types, were selected for data extraction. Table 1 describes the language, type, and implementers involved as per the literature review.

109 members of the polio universe responded to the survey, of whom 83 completed the paper-based survey, and the remaining 26 completed the online tool (Table 2). Across the survey, the majority of respondents had more than ten years of experience with polio eradication activities, and the majority of the respondents worked in Government agencies (62.3%, n=104) and WHO (17.4%, n=29), respectively. The majority of the respondents conducted activities in vaccination (20.8%, n=53), surveillance (17.3%, n=44), and strengthening the delivery system (15.7%, n=40), respectively.

18 KIIs were conducted at the national and sub-national levels to explore in-depth knowledge about polio eradication activities in Bangladesh. Among the 18 KII participants, 17 were at the national level and one was at the sub-national level. Half of the KII participants were affiliated with government, followed by GPEI partners comprising nearly a third (33.3%, n=6) of the participants. Five participants were Surveillance Medical Officers (SMOs) engaged directly with AFP surveillance activities.

The following themes emerged from the analysis of grey literature review, survey, and KII findings.

### ***History of the AFP surveillance in Bangladesh***

Initially, the AFP surveillance in Bangladesh was introduced in 1990 at districts, Upazilas, and major hospitals through the existing government structure. The Government of Bangladesh (GoB) assigned the Upazila Health and Family Planning Officer and the Civil Surgeon as Disease Surveillance Focal Persons (DSFP) at Upazila and district level, respectively, and Medical Officer for Disease Control as Local Surveillance Officers (LSO) [17, 18]. There were two surveillance systems that include Epidemiologic Information System (EIS) administered by the Institute of Epidemiology, Disease, and Research (IEDCR), which is now the active surveillance system, and Monthly Disease Profile (MDP) administered by the Health Information Unit (HIU) at the Ministry of Health (MoH), which is the passive surveillance system. Due to a low number of reported cases, GoB assigned both volunteers and NGO workers in Upazilas and districts in 1996 [18]. The authority involved trained frontline workers, and the grass-root leaders and volunteers named "key informants" trained and mobilized the community to notify and report AFP cases through a series of awareness-building activities. These informants were; i) front line primary health care workers, ii) BRAC volunteers, iii) Imams of local mosques, iv) Union Council members v) village doctors, vi) local healers, vii) EPI outreach sites caretakers, viii) ORS depot holders, ix) contraceptive depot holders, x) NID volunteers, xi) school teachers xii) scouts (12). All KII respondents acknowledged their valuable contribution in identifying AFP cases.

*"EPI did not have that much human resources to conduct the NID and child to child search. There were six lakhs, volunteers, from community and people from these sectors.... they were very committed." KII\_G55.*

*"Their contribution is great... If they did not give information, we would not have been able to strengthen surveillance. They are the real ones.... They provided us much support going door to door.... they also worked with the community, showing sympathy and empathy." KII\_G64.*

In urban areas, international and national organizations including the United States Agency for International Development (USAID), BASICS, Immunization and Other Child Health (IOCH), Urban Primary Health Care Project (UPHCP), and Stop Transmission of Polio (STOP) program supported the primary surveillance system [19]. Finally, the country established comprehensive AFP surveillance in 1997 [20].

To further strengthen surveillance, WHO created the post of Surveillance Medical Officer network in 1999 with support from GPEI. The survey found that 44 respondents had a role in polio eradication, and all the KII respondents accredited the WHO's contribution and their SMO network for strengthening the AFP and VDP surveillance. The network is supported by GPEI and implemented through the Immunization and Vaccine Development (IVD) program of WHO and work closely with the government officials assigned surveillance from the national level to the field level. In 2002, an additional workforce named District Immunization Medical Officer (DIMO) was recruited by EPI using GAVI HSS1 fund for supporting the surveillance, which later merged with SMOs to form Surveillance Immunization Medical Officer, and the number is raised to 64 (SIMO) [20].

The survey findings noted that EPI & WHO has selected the Virology Department of the Institute of Public Health (IPH) as the National Polio Laboratory (NPL) in 1993 to diagnose polio cases. NPL was then formally established in 1995, which is now an established WHO accredited laboratory in Bangladesh. Later in 2005, NPL took the responsibility of measles and rubella surveillance and was re-designated as the National Polio and Measles Laboratory (NPML) [20]. Bangladesh achieved certified standards for ten AFP surveillance performance indicators since 2001. Due to well-established and functioning AFP surveillance, Bangladesh detected 18 cases of wild poliovirus type 1 (WPV1) in 2006, which were imported cases from western Uttar Pradesh state in India. During this outbreak, Bangladesh conducted extensive surveillance and supplementary immunization activities (SIAs) and successfully contained the outbreak.

*"We do not have any indigenous cases since August 22 2000. However, India has long been in endemic status, till 2011. There was always a threat to the importation of Polio. Therefore, once there is any case detection in the neighbouring country through surveillance, surrounded people were vaccinated." KII\_G66.*

The survey and KII data found that environmental surveillance (ES) through testing of sewage water was established in September 2015 in Dhaka (Gulshan or Iztema ground) and Gazipur district.

Using the 'grab' method, 52 samples were collected from selected sites, and 46 samples (88%) were tested at the NPML in July 2016. Initial results suggested that there was no wild poliovirus present in

Bangladesh [21].

In 2018, ES was further extended to Cox's Bazar district, where large numbers of Rohingya refugees live in makeshift camps. Since 2006, no WPV cases were detected in Bangladesh, and a very high AFP surveillance standard coupled with high OPV3 coverage through the EPI was maintained to keep the country polio-free. For more than ten years, Bangladesh maintained the non-polio AFP rate of 2.84% and the stool sample collection rate of 99%. Currently, 162 active surveillance and 787 passive surveillance sites are functional [11, 13, 22]. Thus, Bangladesh was able to develop and maintain AFP surveillance as one of the primary strategies to monitor the impact of polio eradication activities, facilitating prompt poliovirus detection and outbreak response and maintaining the polio-free status across the country. The key events of the polio program in Bangladesh are shown in Figure 2.

## ***Importance of the AFP surveillance in polio eradication***

Among 109 survey respondents, 44 respondents chose AFP surveillance as their primary role. The survey also highlighted that AFP surveillance led by the GoB under the Expanded Program on Immunization (EPI) and supported by the WHO successfully contributed to the decrease in poliomyelitis cases (Figure 3) and in attaining polio-free status for Bangladesh. The EPI program contributed significantly to the AFP surveillance system in the country with the technical support of the skilled SMO network of WHO in 787 surveillance sites across the country. The key informants also emphasized the importance of AFP surveillance.

*"Since I started working, if I speak about the most critical two phases of polio eradication works, one would be the intervention that is the vaccination, and another is the searching for polio patients through surveillance. The surveillance still exists, and we still search for AFP cases,"* said KII\_G36.

## ***Activities and reporting***

SIMOs visited the active surveillance sites once in each epidemiological week to identify potential AFP cases. SIMOs also ensured the preservation of investigation form in the local WHO office, in the Upazila Health Complex, and EPI Headquarters. If any AFP case is identified, SIMOs, with help from government officials, do the necessary investigation and ensure timely transportation to the NPML, maintaining a reverse cold chain according to standard AFP case definition. In the case of positive isolates of wild poliovirus (WPV), NPML informs the national EPI and sends the stool sample to WHO accredited Regional Reference Laboratory in Mumbai, India, to confirm the WPV and genetic sequencing. The reporting structure of AFP surveillance in Bangladesh, including Government and WHO staff, is described in Figure 4.

SIMOs are also responsible for a 60-plus day follow-up of all reported AFP cases to exclude any residual signs [11, 19, 22].

# Key factors driving the success of AFP Surveillance

## High political commitment

Since the independence of Bangladesh in 1971, two major political parties, have dominated the country's politics. As a result, political instabilities have been taken place, including a series of conflicts, strikes and shutdowns threatening all potential sectors as well as the overall development of the country.

Fortunately, the GoB was highly committed to polio eradication efforts including AFP surveillance from the beginning [23, 24]. Around 17% of our survey respondents informed political factor as one of the main reason behind the success.

*"The highest level of political commitment had a special focus on polio eradication. Due to political support, we did not face any difficulty in getting adequate support at political support from all government levels... There was definitely a positive effect from the political side. Otherwise, coming to this point was not possible. Every Government owned the program" KII\_G54.*

## Multi-sectoral collaboration, support and activities:

The online survey found that nearly (44%, n=18) of survey respondents said conducting well-planned, target-oriented surveillance activities were the main success factors for AFP surveillance (Table 3). The survey also identified that the combined efforts and effective strategies of the GoB, EPI, the GPEI core partners, and other international and national NGOs contributed to the success of the AFP surveillance and, ultimately, keeping Bangladesh free from wild polio cases. Both the open survey responses and KIIs signify that the strong collaboration and social engagement among all relevant ministries, local Government, political leaders, political parties, civil society and local NGOs and partners, robust professionalism of the EPI Bangladesh workforce, polio laboratory team of IPH, WHO SMO network, provided technical and financial support, facilitated the implementation and success of the AFP surveillance in Bangladesh.

*"Comparing EPI related interventions over other interventions, every international organization like GAVI, UNICEF, WHO..., altogether worked, and they never delayed any EPI related activities." KII\_G35.*

The SIMO network's tremendous support was a key factor behind this remarkable achievement and was described by one informant as "the backbone of polio eradication in [Bangladesh]" [15, 25].

The EPI personnels, every partner from national to a community level, NGOs, volunteers like traditional health caregivers, religious leaders, and school teachers complimented and supplemented each other to bring a strong synergy in the programme—the government act as the lead of the program. The development partners supported the government financially and technically. The volunteers dedicatedly assisted the field workers in community engagement for making the program a major success.

*"The EPI people are so good than other sectors I have seen; they do their job unconditionally, together with development partners, community volunteers "*KII\_G58.

## Social Environments

Most (53.7%, n=22) of the survey respondents mentioned that the community setting and context were major contributing external factors for successful AFP surveillance (Table 3). The nationwide community participation during NIDs and SNIDs had high visibility in the polio eradication program, including AFP surveillance. The key informants' roles for AFP case tracking, notifying them to nearby health workers and centres, and raising awareness among communities regarding the symptoms and impact of the disease played a significant role in Bangladesh [19].

*"We distributed the AFP message that these types of patients (who are) below the age of fifteen, suddenly they became paralyzed, cannot move are found should be immediately notified to the health facility, to the community volunteers like religious leaders, community leaders, village doctor and traditional healers throughout Bangladesh. ....It helped a lot."* KII\_G66.

The people deliberately did it without any interruption from the community; instead, they got help and cooperation.

## Technology

About (27%, n=11) of the survey respondents identified the technological environment as a facilitating factor that contributed to the success of the surveillance and highlighted the specific role of WHO in supporting the GoB through technical support and the deployment of the surveillance workforce. This support is acknowledged by the GoB and GPEI partners in achieving and maintaining the country's certification standard surveillance system.

## Challenges

In our survey, the majority (38.1%, n=16) of respondents identified external factors as key challenges, which includes political, economic, social, technological environment and others, followed by the process of conducting the activities (33.3%, n=14) and organizational settings (12%, n=5) (Table 3). In our literature review and KII, external factors were also identified as major challenges. Among the mentioned challenges, the following challenges stood out:

## Population Density

Bangladesh is one of the most densely populated countries in the world, with 1,115 people per square kilometre. This dense population was identified as one of the significant challenges for planning AFP surveillance in the country [19].

*"And in our country, where the population is size so much big, the cohort is big.....it was difficult to reach all people." KII\_NG60.*

## Hard to reach the area:

According to geographic location, hydro-geological condition, and socio-economic profile, 1,144 unions (21%) in 6 diverse geographic areas were identified as hard to reach. This area spreads over 257 Upazilas in 50 districts in Bangladesh as per the National Strategy for Water and Sanitation Hard to Reach Areas of Bangladesh [23, 25]. In these areas, thousands of small villages are isolated by rivers, forests, large water bodies ('Haors'), and hills. Many of them remain separated for months by floodwaters with the challenges of travelling in these areas. Therefore, it was always difficult for health care providers to access those areas and conduct regular reporting in remote areas with little or no health infrastructure support and active search for AFP cases [5, 26]. Respondents to the KII expressed similar experiences:

*"Many places of Noakhali, Chittagong, riverine areas of Barishal, Haor areas in Kishorgonj district have hard to reach areas where communicating is real hard. Extra support was given there through the surveillance team." KII\_NG56.*

*"The Haor areas were hard to reach and densely populated. It is hard to reach, but some percentages could be covered once we reach with a team. So, micro-planning was done this way for those areas to visit them once a month for vaccination and surveillance " KII\_NG56.*

## The population at risk

Bangladesh shares borders with India and Myanmar and also has refugee camps near the Myanmar border. India was polio-endemic until 2014, and the presence of WPV circulation close to the Bangladesh-India border was alarming. Myanmar had an outbreak of cVDPV, posing a potential threat of importation [27]. Bangladesh had maintained polio-free status since 2000; however, 18 cases of imported Wild Polio Virus 1 (WPV1) from the state of Uttar Pradesh, India, were reported in Bangladesh in 2006 [20].

cVDPVs across Myanmar created public health concerns in both countries. Rohingya refugees labelled by the GoB as Forcibly Displaced Myanmar Nationals (FDMN) live in camps in Cox's Bazar district in southeast Bangladesh, and they posed an additional challenge in keeping Bangladesh polio-free.

The GoB conducted special microplanning for the disadvantaged groups, which included communities like snake-charmers, people living in boats and in islands ('chars') within rivers, tea garden workers,

brothel inmates, minority groups, slum people, children of working mothers, and the floating population [22]. Throughout Polio SIAs, when vaccinators searched house to house, they also did queries about new AFP cases, especially in high-risk areas [5].

## Transition

As we remain on the verge of eradicating polio globally, the GPEI has started to transition gradually in close consultation with national partners globally. In Bangladesh, GPEI planned to decline the support in 2019. The transition of polio assets created by GPEI support is critical to preparing the country for a smooth transition. According to the transition plan, AFP surveillance will be fully funded by the GoB, and the SIMO network will be replaced by Government, and there will be a creation of new epidemiologist/public health positions in the Government. However, in the literature [20], the free text of the survey, and KII response, uncertainty in implementing the plan and maintaining the current quality surveillance have emerged. One KII respondent said,

*"Technical knowledge is not built in one day. It is not the time to stop the donor support in Bangladesh as the Government will not be able to run these programs. Bangladesh is on a strong foothold."* KII\_NG60.

*"Without SMOs, AFP surveillance would not be the same" (Female\_54\_virologist). "Now Bangladesh Government plans to absorb this network in some way. Ultimately the Government will take over the SIMO network according to the polio transition plan."* KII\_NG60.

## Beyond AFP Surveillance

In Bangladesh, an extensive national disease surveillance system and a national laboratory were established to support GPEI. Additionally, a team of skilled technical staff and a network of trained community health workers, social mobilizers, and volunteers were developed. Bangladesh is currently working towards other global and national goals of disease elimination and control, particularly VPDs. The disease surveillance system commenced based on AFP surveillance, and surveillance for measles-rubella, NNT, Japanese Encephalitis JE, AEFI, and other VPDs was integrated and implemented by the government staff with the assistance of SIMO [20]. We got the same responses from the free texts of the survey and from the KII responses as well. Since 2005, the SIMOs have performed measles surveillance. Later SIMO network was also given the responsibility of tracking acute encephalitic syndrome (AES).

*"Now there are lots of government program programs like Malaria program, the Rohingya program, nutrition program where the same health worker is responsible for giving support who worked for polio."* KII\_NG55.

The SIMO network was also responsible for acute encephalitic syndrome surveillance, including training and orientation on AEFI surveillance since it was included in the program in 2002. It was used to strengthen the RI, developing different EPI guidelines and plan and assisting during natural disasters

because of their exceptional skill acquired through working in polio eradication initiatives and community mobilization in Bangladesh [19].

*"Gradually, we (SMOs) entered the EPI. So, now speaking about new vaccine introduction, routine EPI monitoring, then rapid convenience assessment, data quality assessment, our SMOs are involved. "Measles elimination, Rubella CRS control, tetanus elimination status should be maintained till certification by us (SMOs)" KII\_NG55.*

SIMOs is currently also engaged in promoting Universal Health Coverage, strengthening malaria control, eliminating Kala-azar, and executing emerging and re-emerging infectious diseases surveillance and integrated disease surveillance program (IDSP) [20].

The SMO network has been regularly utilized in different national emergencies and natural disasters and cyclones such as cyclone Sidr (2007), Aila (2009), and the 2004 tsunami and regular floods in the past two decades.

## Discussion

Vaccination has contributed significantly to the success of public health in eradicating one feared disease of history, smallpox, and is now on the brink of eliminating the crippling disease poliomyelitis. Bangladesh has achieved significant progress in routine immunization for children, a globally recognized success story [11, 23]. Due to the GPEI initiative, America, Western Pacific, and Europe were certified as polio-free in 1994, 2000, and 2002 [28]. Though Bangladesh was the last country to eradicate smallpox, it pioneered polio eradication in the Southeast Asian region by stopping polio transmission in 2000. This success was made possible through a set of strategies and sustained effort by the Government, development partners, and the community effort; AFP surveillance played a crucial role as one of the leading and essential strategies [22, 29].

This study highlights that the major factors that influenced the success of AFP surveillance included high-level political commitment, technical and financial support, multi-sectoral collaboration and support, community participation, and laboratory network.

Although the Ministry of Health and Family Welfare led the polio surveillance system, the role of other ministries and departments is noteworthy. Specifically, the Ministry of Education, Home, and Local Government actively mobilized the community and their workforce to support surveillance of polio cases. Clearly defined targets, goals, outcomes for AFP case detection, stool sample collection, and testing rates, including coverage evaluation surveys to measure OPV 3 coverage, provided an evidence-based approach to monitoring the success of the surveillance system and other vaccine-preventable diseases. It also required a robust multi-sectoral collaboration and involvement of other stakeholders like NGOs and community volunteers [1, 4, 5, 30].

GPEI has played a significant role in strengthening the laboratory network, disease surveillance capacity, and outbreak response worldwide. Among the GPEI core partners, WHO provides the bulk of technical assistance to the Government in the setting up and functioning of the polio surveillance at national and sub-national levels and also supports the quality assurance and standardization of surveillance laboratories by offering a highly trained workforce for timely detection of polio cases [31, 32]. WHO provided technical support to the Ministry of Health and Family Welfare, the National Polio and Measles Laboratory (NPML), and built a well-established polio surveillance system through the SIMO network. Fully accredited National Polio Laboratory by WHO and technical, logistics, and operational support from GPEI enabled the GoB to detect and confirm wild poliovirus cases. NPL is used for measles and rubella surveillance and transformed into National Polio and Measles Laboratory.

Similar to Bangladesh, in Nepal, the Preventable Disease (IPD), a WHO-supported national program, formed the backbone of AFP surveillance. In India, a large workforce of medical surveillance officers (SMOs) from the National Polio Surveillance Project (NPSP) played a crucial role in surveillance activities both at the national and state level [32].

The study shows that in Bangladesh, key informants or community volunteers were also involved in identifying and notifying AFP cases to the assigned health authority at different administrative levels as part of community surveillance. Engaging communities to fight against Polio was also adopted in many African countries, including Nigeria, Somalia, Kenya, Ethiopia, and Zimbabwe [6, 32–35]. In the Afghanistan context, 'mullahs' (religious leaders), traditional healers, health service providers, teachers, parents, and others are trained to detect AFP cases in their community [36].

Environmental surveillance (ES) was launched in six countries of SEAR, including Bangladesh, India, Indonesia, Myanmar, Nepal, and Thailand. According to Polio Environmental Surveillance Expansion Plan, Bangladesh also falls under the priority criteria for expanding ES sites because of the high risk of importation to geographical proximity to potential polio virus-infected areas. Another AFP surveillance indicators evaluation study from 2011 to 2015 emphasized the necessity of ES expansion to complement the ongoing AFP surveillance activity [4, 37, 38].

This study revealed that low performance of AFP surveillance initially, during the transition, in a hard-to-reach area, and among the so-called 'floating' population, dense population, and importation threat were barriers to implementing the AFP surveillance activities. These challenges match with challenges found in other countries as well. Six countries of Africa: Chad, the Republic of the Congo, Côte d'Ivoire, Gabon, Guinea, and Niger are still not meeting the required benchmark indicators for adequate specimen collection [39]. According to a global report on polio transition planning, WHO says that due to funding decrease, regional and country-level WHO offices will be exposed to the risk of disrupting the main EPI functions, and especially the disease surveillance activities [40]. Similarly, in Bangladesh, the Polio transitioning poses risks and challenges in implementing the plan of substituting the staff, resulting in compromised surveillance. In addition, as the development partners supported most of the tasks and funding, it will be crucial for Bangladesh to sustain the standard surveillance system. Therefore,

Bangladesh Govt. has decided to conduct the transition in a phased manner, gradually withdrawing the technical support of WHO [20]. In the same manner, 13 out of 16 countries have already developed national transition plans, and Ethiopia, South Sudan, Pakistan and Afghanistan have emphasized the support of WHO and other partners in this crucial phase regarding transitioning of the essential functions to the Government [41, 42]. The poliovirus continues to remain a major challenge for remote and inaccessible places worldwide. Some areas are sparsely populated, some are densely packed, river beds of Lake Chad, and some areas are in conflict-affected countries [43]. Surveillance efforts need to be strengthened to reach mobile and migrant populations, including internally displaced populations and refugees. A good example of reaching out to the remote population for immunization services and social mobilization in the Kosi riverine area in Bihar, India, was a social mobilization network (SMNet), set up by UNICEF. The model was replicated in other polio-endemic states in India and other countries such as Afghanistan and Nigeria [5, 43]. In such difficult areas, tapping into the communities and engaging them is key to overcoming the challenges in surveillance [36]. However, many countries experienced the emergence of cVDPVs that resulted in outbreaks of paralytic Polio. Pakistan, and Afghanistan, China, Malaysia, and the Philippines showed an outbreak of cVDPV type-2 [44]. Sharing a border with Myanmar and India (shares border with Pakistan and China), Bangladesh always poses a risk of importing the poliovirus [22].

Surveillance for AFP is a fundamental strategy of the GPEI, and ample resources have been invested. Multiple disease surveillance interventions are integrated with AFP surveillance, which becomes standard practice in many countries for measles and rubella surveillance [4, 9]. According to a survey conducted in 2000, 26 of the 32 countries used AFP surveillance resources for other infectious diseases like measles, neonatal tetanus, cholera, meningitis, and yellow fever [45]. Similarly, by 2003, 131 of 198 countries globally were using the platform of AFP surveillance systems surveillance of other VPDs [4]. Bangladesh also started the AFP surveillance platform beyond the polio program to other health initiatives, especially in other disease surveillance like surveillance for measles-rubella, NNT, Japanese Encephalitis JE, AEFI, and will continue stretching far through the transition plan. For emergencies, the SIMO network has been regularly utilized in different national emergencies and natural disasters and cyclones such as cyclone Sidr (2007), Aila (2009), and the 2004 tsunami and regular floods in the past two decades<sup>17</sup>. Also in COVID-19 crisis in Bangladesh, SIMOs were deployed to support all aspects of the COVID-19 response in their representative districts. They helped in coordinating field activities, capacity building in Infection Prevention & Control, IPC [46] and contact tracing, ensured prompt and safe transportation of laboratory samples and other supplies, conducting surveillance and resuming lifesaving vaccination throughout the country.

## Conclusions

As the world is so close to eradicating polio, the assets, knowledge, lessons learned, and functions of the polio programme could be transferred to other health programmes. The recent COVID-19 crisis could be made a perfect example using this immense knowledge and deploying the AFP surveillance team to identify the active case of COVID-19 and also AFP surveillance simultaneously. Bangladesh is a country

where significant AFP surveillance personnel and assets have been identified. Therefore, it is high time for the AFP surveillance team to provide guidance and support to the Government in COVID-19 surveillance and training and sensitizing health workers, helping in communication and supporting the laboratories.

## **Declarations**

### **Ethical approval and consent to participate**

Ethical approval to conduct the study was obtained from the institutional review board of the BRAC James P Grant School of Public Health, BRAC University, Bangladesh (IRB References No: 2018-016-IR). For online version of the survey, an option was given at the beginning of the survey in Qualtrics © asking consent to participate in the study. For both paper-based version of the survey and KII, informed written consents were taken from all participants.

### **Consent for publication**

Not applicable.

### **Availability of data and materials**

Data and publications from this project will be open access and available via an online repository

### **Competing interests**

The authors declared no competing interests.

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### **Authors' contributors**

HBA, YM, OA and MS conceived the paper, contributed to the data analysis, and reviewed the final draft for intellectual content. HBA wrote the initial drafts of the manuscript. HBA and SN contributed to the data analysis. AK reviewed multiple drafts of the manuscript for intellectual content. YM, SN, BZI, AK, OA and MS reviewed the final draft of the manuscript for intellectual content. All co-authors provided editing support in finalizing the manuscript.

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## Patient consent for publication

Not Required

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## Tables

**Table 1**

Categories of the identified grey literature

<b>Category</b>	<b>Frequency</b>	<b>Percent</b>
	<b>n= 92</b>	
<b>Language</b>		
Bangla	7	7.6
English	85	92.4
<b>Type of document</b>		
Bulletin	13	14.1
Scientific journal	8	8.7
Report	5	5.4
Fact sheet	6	6.5
Newspaper	2	2.1
Power point presentation	4	4.3
Manual	4	4.3
Protocol	1	1
Other	49	53.3
<b>Type of Implementers</b>		
Government	61	66.3
GPEI core partners	40	43.5
Academic organization	8	8.7
Funding and implementing organization	31	33.7
Other	24	26

**Table 2**

Profile of the survey respondents

<b>Variables</b>	<b>Frequency</b>	<b>Percent</b>
	<b>n= 109</b>	
<b>Years involved with polio eradication activities</b>		
<5 years	16	14.7
6-15 years	29	26.6
16- 25 years	43	39.4
25+	21	19.3
<b>Level in polio eradication activities</b>		
Global	18	10.1
National	46	25.8
District	66	37.1
Sub-district	48	27.0
<b>Organization affiliation</b>		
WHO	29	17.4
Rotary International	2	1.2
UNICEF	7	4.2
Center for Disease Control, US	3	1.8
NGO Implementing Partners	7	4.2
Government	104	62.3
Academic/research institution	4	2.4
Other	11	6.6
<b>Primary role in polio eradication activities</b>		
Resource mobilization	5	2
Partnership/alliance development	15	5.9
Strategy development and planning	29	11.4
Strengthening delivery systems	40	15.7
Vaccination	53	20.8
Surveillance	44	17.3
Community engagement	30	11.8

Monitoring & Evaluating	32	12.5
Others	7	2.7

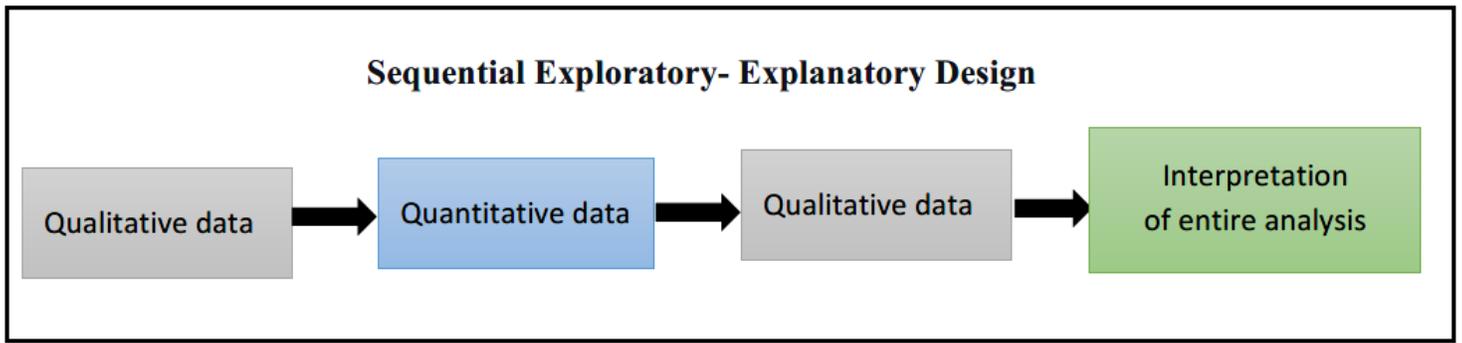
*\*Multiple responses*

**Table 3**

Contributing factors and challenges of AFP surveillance implementation (On-line survey)

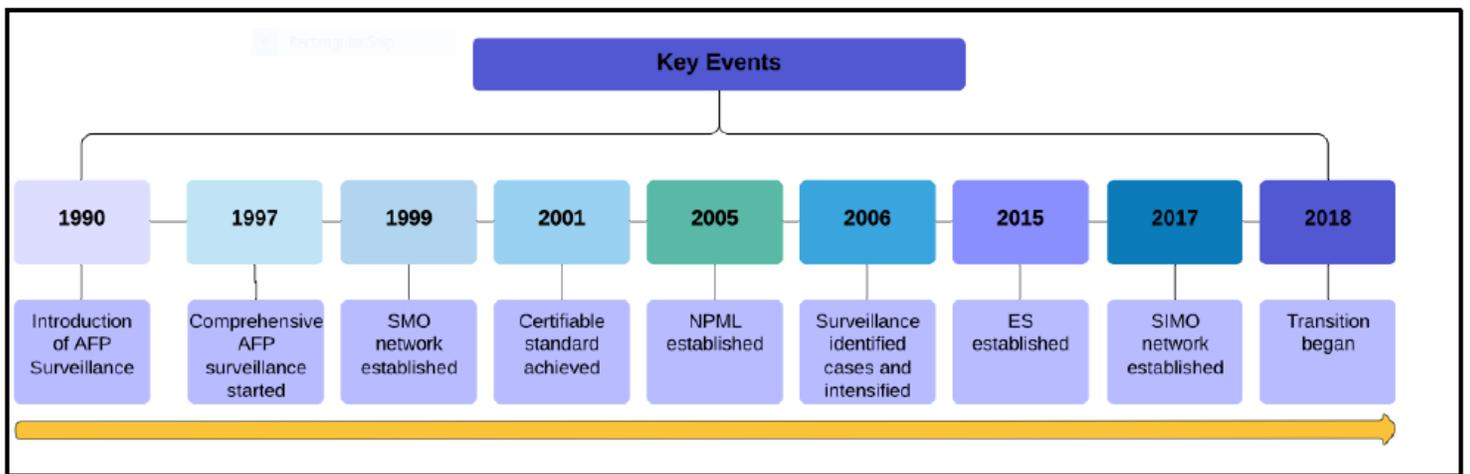
<b>Variables</b>	<b>Frequency (N)</b>	<b>Percentage (n %)</b>
<b>Internal contributor surveillance</b>		
Process of conducting the activities	18	43.90
Polio eradication program characteristics	13	31.71
Organizational settings	7	17.07
Characteristics of individuals within your organization	3	7.32
<b>External contributor surveillance</b>		
Social environment	22	53.66
Technological environment	11	26.83
Political environment	7	17.07
Economic environment	1	2.44
<b>Challenges of Surveillance</b>		
External settings	16	38.10
Process of conducting the activities	14	33.33
Organizational settings	5	11.90
Polio eradication program characteristics	5	11.90
Attitude of individuals associated with your organization involved in polio eradication activities	2	4.76

## Figures



**Figure 1**

Sequential exploratory-explanatory mixed-method for the current study



**Figure 2**

Key events of the polio program, Bangladesh

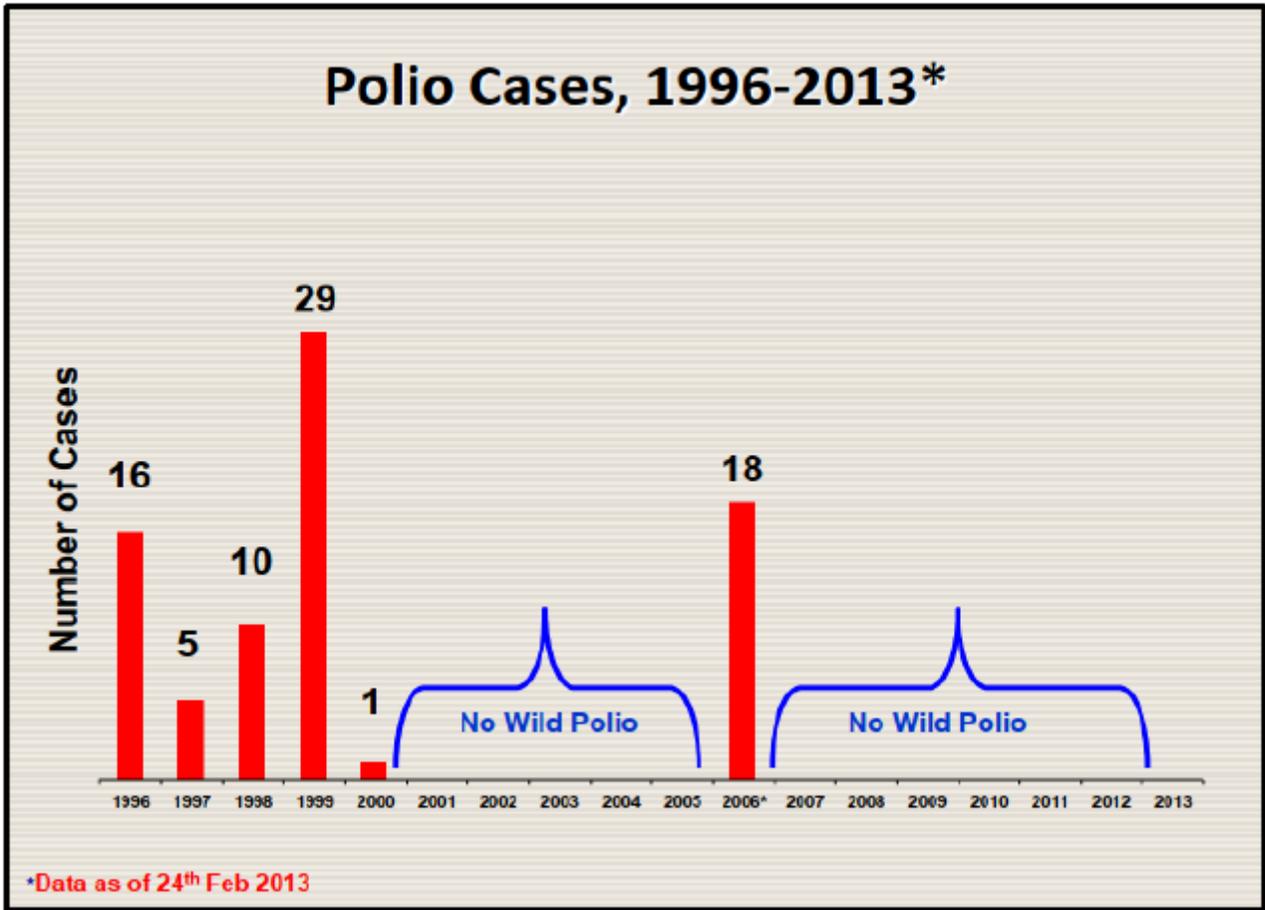
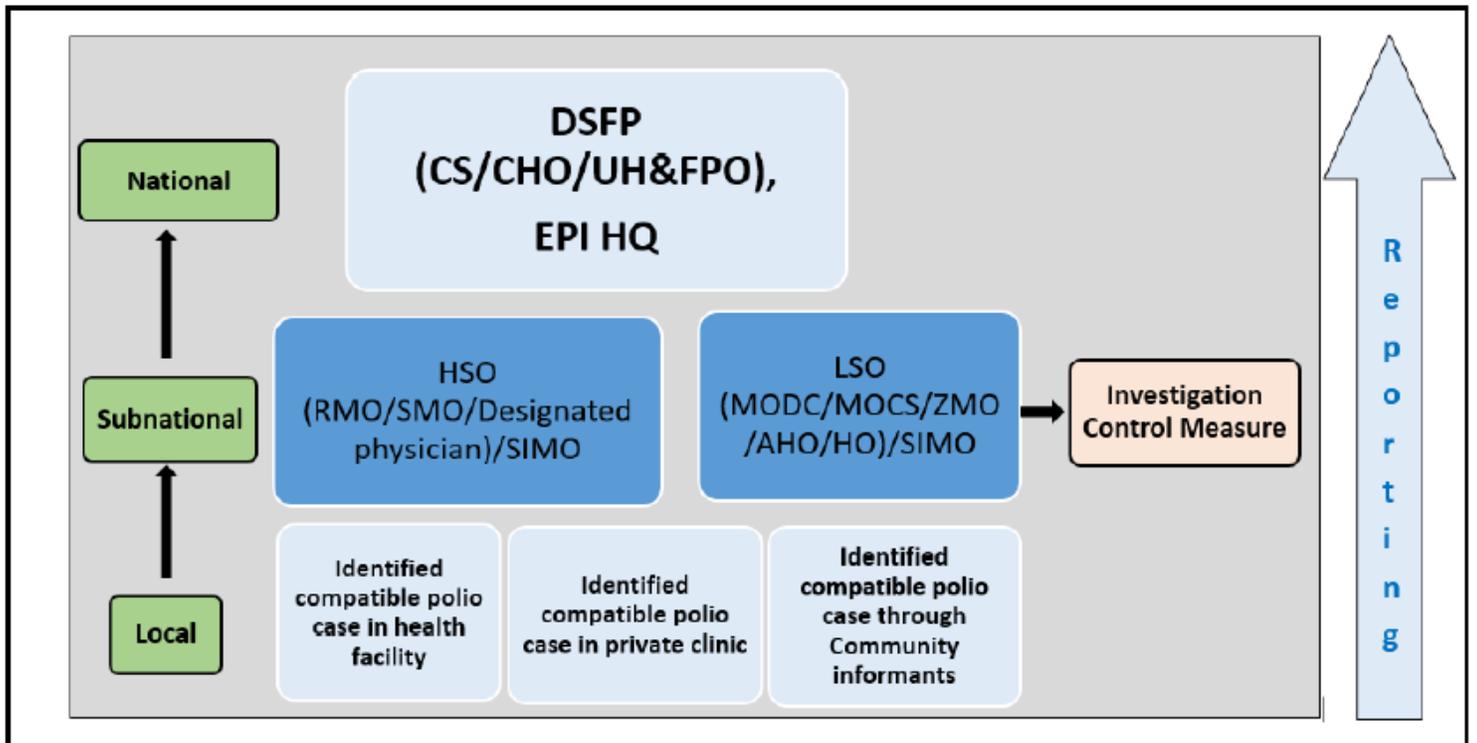


Figure 3

Polio cases in Bangladesh, 1996-2013\*



## Figure 4

The structure and reporting system of the polio program in Bangladesh

## Supplementary Files

This is a list of supplementary files associated with this preprint. Click to download.

- [SurveyToolSTRIFE.pdf](#)