



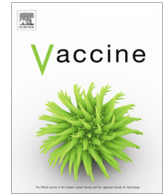
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The immediate impact of the COVID-19 pandemic on polio immunization and surveillance activities

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ARTICLE INFO

Article history:

Received 7 June 2021

Received in revised form 23 September 2021

Accepted 12 October 2021

Available online xxx

Keywords:

Global polio eradication

COVID-19

Circulating vaccine-derived poliovirus

ABSTRACT

In addition to affecting individual health the COVID-19 pandemic has disrupted efforts to deliver essential health services around the world. In this article we present an overview of the immediate programmatic and epidemiologic impact of the pandemic on polio eradication as well as the adaptive strategic and operational measures taken by the Global Polio Eradication Initiative (GPEI) from March through September 2020. Shortly after the World Health Organization (WHO) declared a global pandemic on 11 March 2020, the GPEI initially redirected the programme's assets to tackle COVID-19 and suspended house-to-house supplementary immunization activities (SIAs) while also striving to continue essential poliovirus surveillance functions. From March to May 2020, 28 countries suspended a total of 62 polio vaccine SIAs. In spite of efforts to continue poliovirus surveillance, global acute flaccid paralysis (AFP) cases reported from January–July 2020 declined by 34% compared with the same period in 2019 along with decreases in the mean number of environment samples collected per active site in the critical areas of the African and Eastern Mediterranean regions. The GPEI recommended countries should resume planning and implementation of SIAs starting in July 2020 and released guidelines to ensure these could be done safely for front line workers and communities. By the end of September 2020, a total of 14 countries had implemented circulating vaccine-derived poliovirus type 2 (cVDPV2) outbreak response vaccination campaigns and Afghanistan and Pakistan restarted SIAs to stop ongoing wild poliovirus type 1 (WPV1) transmission. The longer-term impacts of disruptions to eradication efforts remain to be determined, especially in terms of the effect on poliovirus epidemiology. Adapting to the pandemic situation has imposed new considerations on program implementation and demonstrated not only GPEI's contribution to global health security, but also identified potential opportunities for coordinated approaches across immunization and health services.

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1. Introduction

In addition to widespread morbidity and mortality, the 2019 novel coronavirus disease (COVID-19) has compromised public health systems around the world and disrupted delivery of essential health services, including efforts to achieve polio eradication.

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² Disclaimer: *The findings and conclusions in this report are those of the authors and do not necessarily represent the official position of the Centers for Disease Control and Prevention (CDC).*

<https://doi.org/10.1016/j.vaccine.2021.10.028>

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When WHO declared a global pandemic on 11 March 2020, the Global Polio Eradication Initiative (GPEI) was already facing significant challenges to polio eradication due to outbreaks of circulating vaccine-derived poliovirus type 2 (cVDPV2) in multiple countries and endemic wild poliovirus type 1 (WPV1) transmission in Afghanistan and Pakistan [1]. Nevertheless, due to the overwhelming threat to global health security generated by COVID-19, the GPEI initially redirected the programme's significant human resources and other assets to tackle the pandemic and suspended house-to-house supplementary immunization activities (SIAs). The interruption of these eradication-focused activities coupled with disruptions to delivery of essential immunization services allowed poliovirus transmission in established outbreaks to persist and created the potential for spread to new areas. In response to these growing threats of paralysis for individual children and the global

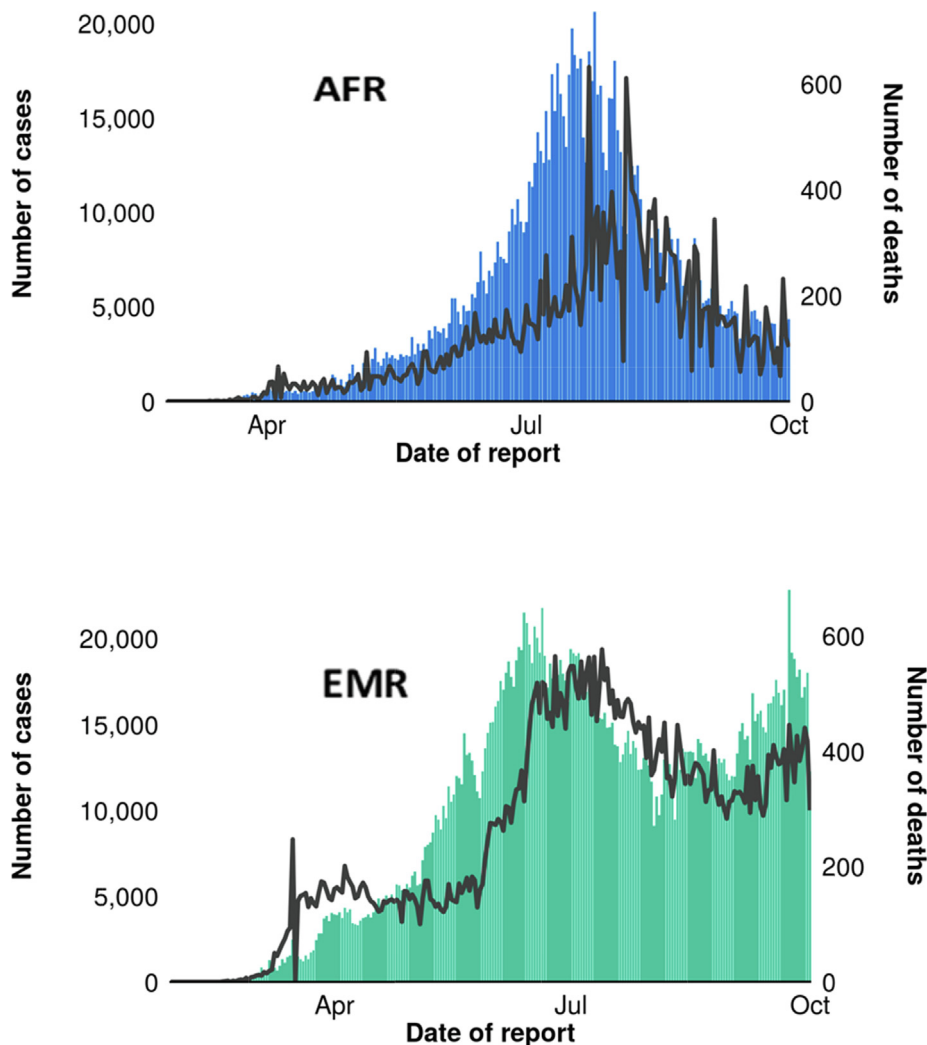
eradication goal itself, the GPEI implemented a range of critical short-term adaptations at the global, regional, and country levels to safely sustain surveillance and immunization services in the face of the continuing pandemic.

Given the widespread, recurring waves of the global COVID-19 pandemic extending into 2021 and the potential for prolonged concomitant disruptions to public health programs in many countries, attempting to fully analyze the consequences of the pandemic at this time remains problematic. In this article we focus on the immediate programmatic and epidemiologic impact of the COVID-19 pandemic on polio eradication as well as the adaptive strategic and operational measures taken by GPEI during the initial emergency response (March-June 2020) and polio program resumption phase (July-September 2020). Through this descriptive analysis of the situation and response for these critical seven months, we provide not only an historical record and outline of lessons learned during the acute period after the pandemic began, but also a framework for a future, more comprehensive, investigation. We include an initial overview of the status during the para-pandemic period from October 2020 to September 2021; however further analysis is planned after the pandemic is controlled in

order to fully assess the consequences of COVID-19 and the capacities of GPEI and individual countries to adapt.

1.1. COVID-19 context (March-September 2020)

Detailed global tracking of COVID-19 conducted by WHO and others demonstrates that no region of the world has been spared during the pandemic [2]. Fig. 1 shows COVID-19 cases and deaths reported in the African (AFR) and the Eastern Mediterranean (EMR) regions, the two areas in the world also detecting WPV1 or cVDPV2 transmission between March-September 2020. Although variable testing and case detection capacities make both inter- and intra-regional comparisons problematic [3], all countries in both regions have reported COVID-19 transmission and are presumed to be at ongoing risk for the virus. South Africa, the country reporting the most COVID-19 cases in Africa, has been free from poliovirus for many years, but during our review period 13 of the 47 countries in the region had to deal with simultaneous outbreaks of COVID-19 and cVDPV2, often in the same sub-national areas [4]. Between March-September 2020 Iran, Iraq, Pakistan, and Saudi Arabia reported the highest COVID-19 case counts in EMR [5]. Of these



Source: World Health Organization Health Emergencies Program

Fig. 1. Number of COVID-19 cases (bars) and deaths (line) reported in the African Region (AFR) and Eastern Mediterranean Region (EMR) , 11 March-1 October 2020.

countries, only Pakistan also had ongoing poliovirus transmission, but 6 of the 22 countries in the region, including Afghanistan, reported both COVID-19 and WPV1 or cVDPV2.

2. Emergency Phase (March-June 2020)

2.1. Initial GPEI response

Following the WHO declaration of COVID-19 as a pandemic on 11 March 2020, the Polio Oversight Board (POB) of the GPEI issued an urgent series of recommendations on 24 March 2020 to country and regional polio programmes [6]. In recognizing the imperative for global solidarity to combat the pandemic and GPEI's extensive network of dedicated staff and infrastructure, the POB called on national polio eradication programmes to prioritize support for the response to COVID-19 for the following 4–6 months. Consistent with wider WHO guidelines to temporarily suspend all mass vaccination campaigns as part of measures necessary to ensure safe delivery of public health programs during COVID-19 [7], the POB specifically recommended that all outbreak response SIAs be halted until 1 June 2020 and all preventive SIAs be postponed until the second half of the year. However, the POB also advised the critical functions of polio surveillance should continue where safe for frontline health workers and should be paired with COVID-19 surveillance wherever possible.

To assist country polio programme implementation of these POB strategic recommendations, on 25 March 2020 the GPEI provided further specific guidelines on supporting the pandemic response [8]. The guidelines emphasized important steps to ensure polio eradication programme continuity by maintaining critical functions for polio eradication and by planning for a fast and effective resumption of polio SIAs as soon as the public health situation with COVID-19 allowed. At the global level, the GPEI created a *Continuity Planning and Facilitation Group* (PFG) with the following key objectives: 1) to facilitate development and tracking of a comprehensive global level GPEI workplan in support of regional and country polio-eradication activities to adjust to the COVID-19 pandemic; 2) to support alignment and coordination both within GPEI and externally with the Essential Programme on Immunization (EPI) partners to implement this plan; and 3) to identify and flag any long-term strategic adjustments required in the *Polio Endgame*

Strategy 2019–2023 to ensure sustainable, effective programme operations in the aftermath of the COVID-19 pandemic.

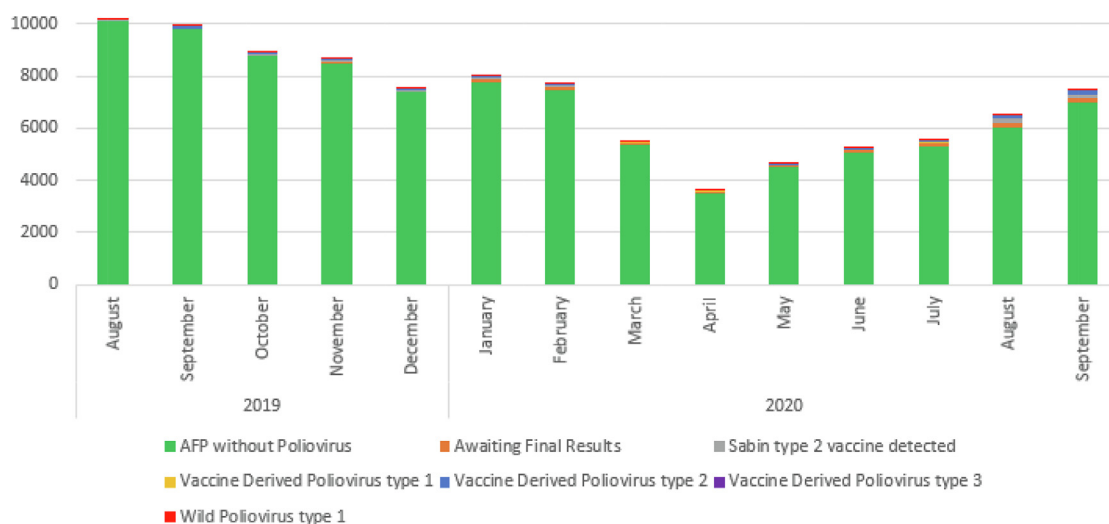
2.2. Initial programmatic impact of the COVID-19 pandemic

In response to the POB call to action in March 2020, over 31,000 key polio staff along with operational assets in both outbreak and endemic countries were re-directed in support of the response to COVID-19 [9]. GPEI staff were integral members of WHO regional COVID-19 Incident Management System Teams tasked with directing the pandemic response. At the country level, the extensive polio surveillance and laboratory networks were utilized to provide training and implement COVID-19 case detection, contact tracing, laboratory testing, and data management. Polio emergency operations centers at both national and sub-national levels in the endemic countries expanded their scope to serve as central locations to coordinate data collection and response to the public health threat from COVID-19. Polio front line workers (FLWs) at the community level were mobilized to provide information on COVID-19 and assist with local case detection.

While GPEI's strategic decision to halt SIAs and repurpose polio staff to combat COVID-19 was deemed a necessary imperative for global health security, these steps, along with pandemic-related disruptions to air and ground transportation, sporadic country lockdowns, and restricted population movements, all impacted the continuity of the polio programme and initially limited the potential for rapidly resuming full scale eradication activities.

2.2.1. Surveillance

In addition to the standard parameters traditionally employed for tracking the sensitivity of global poliovirus surveillance, the GPEI developed supplemental indicators to flag gaps in either acute flaccid paralysis (AFP) surveillance or environmental surveillance (ES) concomitant with the pandemic. The surveillance system continued to regularly detect poliovirus during the pandemic; however, Fig. 2 confirms that global AFP reporting declined dramatically following the initial onset of COVID-19. Additional analysis has found that global AFP cases reported from January–July 2020 declined by 34% compared with the same period in 2019 along with decreases in the mean number of environment samples collected per active site in the critical areas of AFR and



Source: WHO

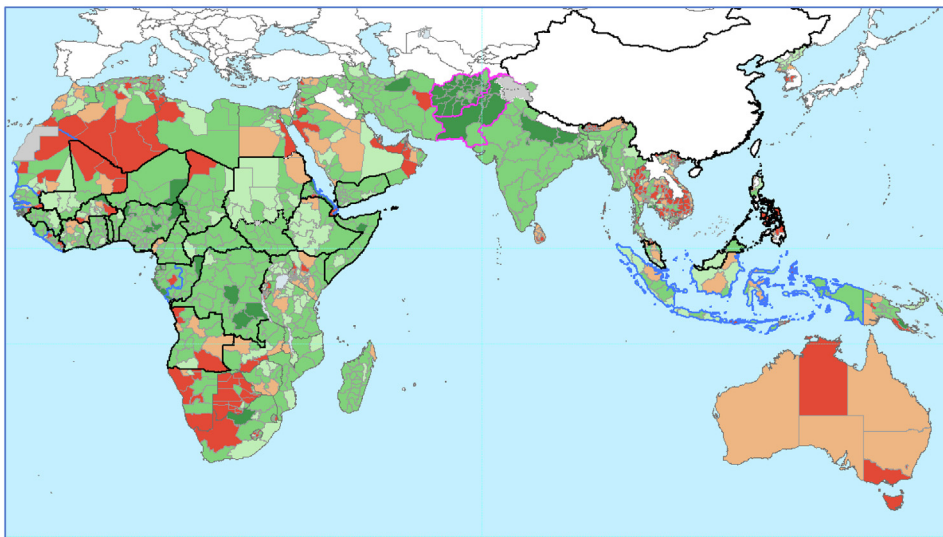
Fig. 2. Global epidemiologic curve of results of acute flaccid paralysis cases detected August 2019–September 2020.

EMR [10]. Due to transport bottlenecks and/or diverted workloads secondary to COVID-19, the WHO-accredited polio laboratories in AFR, EMR, and the South-east Asia region tested 46% fewer AFP specimens and 33% fewer ES samples for the same months in 2020 compared to 2019 [10].

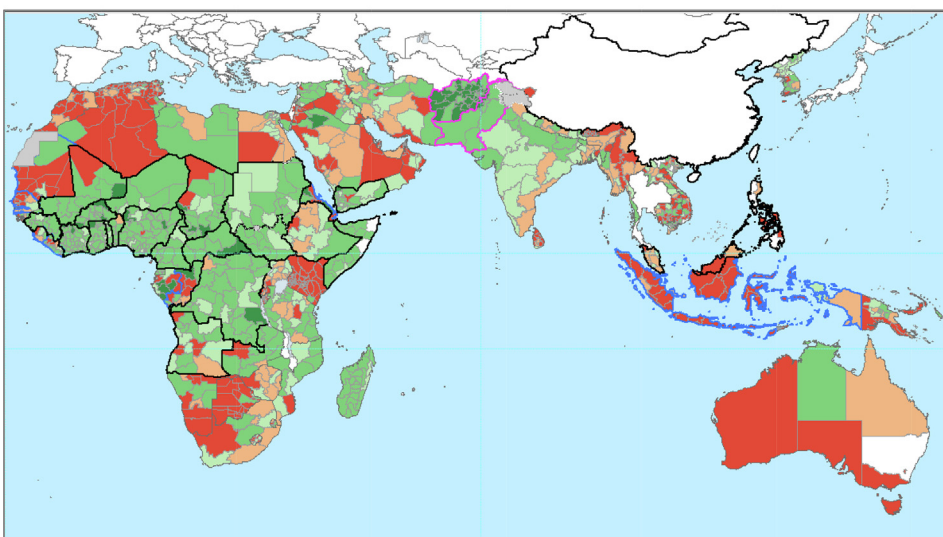
While most countries considered vulnerable to polio transmission continued to maintain national-level nonpolio AFP (NP/AFP) rates of ≥ 2 cases/100,000 children under 15 years of age, the threshold determined by GPEI as sufficient to detect poliovirus if present, several critical outbreak countries (e.g., Guinea, Sudan, Ethiopia, Yemen) dropped below this quality at the sub-national

level (see Fig. 3) and also experienced a drop in ES sample collection during April-September 2020 [11]. Multiple factors could account for these changes and country-specific operational assessments would be required before attributing the declines to specific aspects of the pandemic. Local operational circumstances, including variable compliance with physical distancing measures imposed to slow transmission of COVID-19, may have contributed differentially to an overall decline in AFP cases. However, the overall increase in the number of pending cases in March-April 2020 (see Fig. 2) is indicative of widespread delays driven primarily, but not always, by the inability to transport specimens either

April-September 2019



April-September 2020



Source: WHO. Data as of 15 Oct 2020

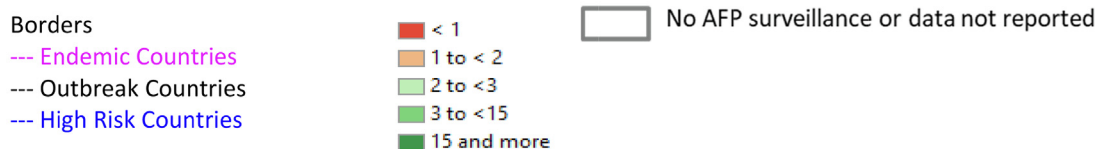


Fig. 3. Sub-national non-polio acute flaccid paralysis (NPAFP) rate (# /100,000 children under 15 years of age), April-September 2019 and April-September 2020.

within or between countries due to COVID-19-related issues. This operational challenge plus the demonstrated decline in AFP cases and ES collection indicate a reduction in the overall sensitivity of polio surveillance during the early phase of the pandemic which contributed to the delayed detection of cVDPV outbreaks in Sudan and Yemen [10].

2.2.2. Polio vaccine SIAs

From March to May 2020, 28 countries suspended a total of 62 polio vaccine SIAs, including crucial efforts to eradicate WPV in the endemic countries, stop ongoing cVDPV outbreaks (primarily cVDPV2), and provide additional protection against polio types 1 and 3 among vulnerable populations (See Fig. 4) [12]. Concerns about COVID-19 also delayed implementation of planned inactivated polio vaccine (IPV) 'catch-up' campaigns in 14 countries which were intended to provide type 2 immunity and prevent cVDPV2 cases among targeted birth cohorts who had missed IPV vaccination due to earlier vaccine supply issues between 2016 and 19 [12].

2.2.3. Global polio vaccine management

The suspension of SIAs generated additional challenges for global vaccine supply management. The interruptions stretched national storage capacities in countries awaiting implementation of planned SIAs and oral polio vaccine (OPV) suppliers were forced to face the possibility of discontinuing production as they also reached the limits of their cold chain capacity. Furthermore, the rapid resumption of global vaccine delivery was severely compromised by major disruptions of international airfreight and increased transport costs due to the pandemic.

2.2.4. Essential Programme on Immunization (EPI) and other vaccine preventable disease (VPD) control SIAs

Although most countries managed to continue some level of delivery of routine vaccines, in May 2020 25 of 29 (86%) of countries in AFR and 8 of 12 (67%) of countries in EMR reported that outreach services critical to immunizing their most vulnerable

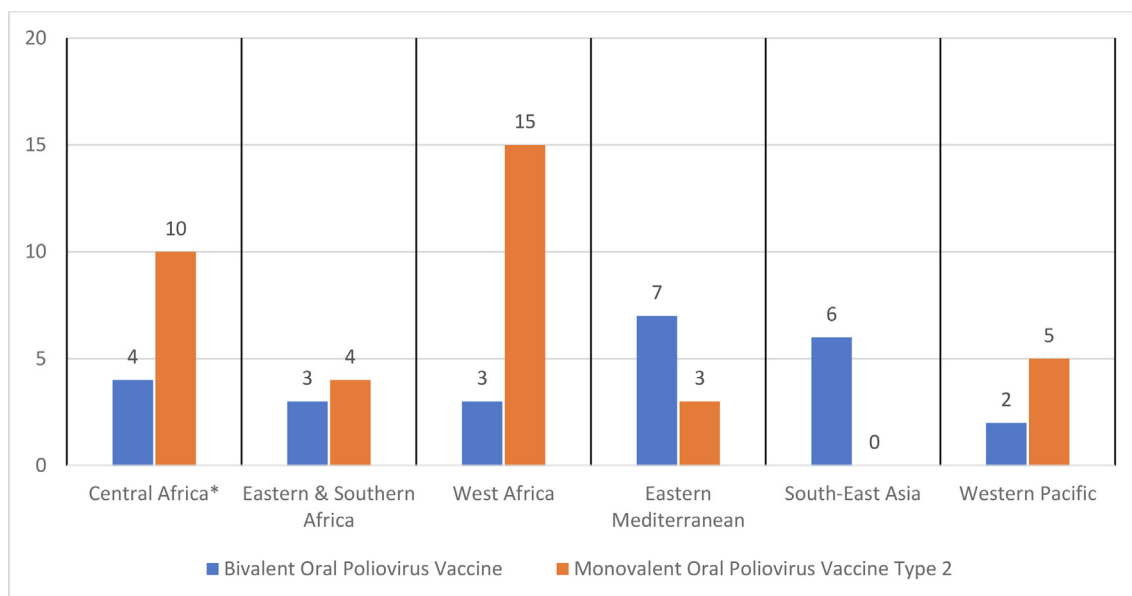
populations were either severely or partially disrupted [13]. These disruptions were due to a combination of pandemic-related causes: lockdowns and/or transportation reductions, community concerns about COVID-19 infections, and supply chain interruptions. A WHO review of administrative vaccination data in the AFR indicated that, while disruptions were not uniform, there was a significant decline in the monthly average number of vaccine doses provided in 13 of 15 assessed countries during the first six months of the pandemic compared to the same months in 2018 and 2019 [14]. More specific quantitative analysis is available for a populous area in Pakistan at high-risk for polio transmission. In Sindh province EPI coverage at the start of the pandemic dropped sharply for all antigens, including for the first dose of oral polio vaccine (OPV1) which declined by 56% during the COVID-19 lockdown period of March-May 2020 compared to the prior six months [15].

According to WHO, 57 SIAs intended to control VPDs other than polio were suspended between March-September 2020 [12]. Most of these interrupted campaigns planned to use measles (M) or measles/rubella (MR) containing vaccine and were targeted to many countries with ongoing polio outbreaks.

2.3. Initial epidemiologic impact of the COVID-19 pandemic

2.3.1. Modelling and risk analysis

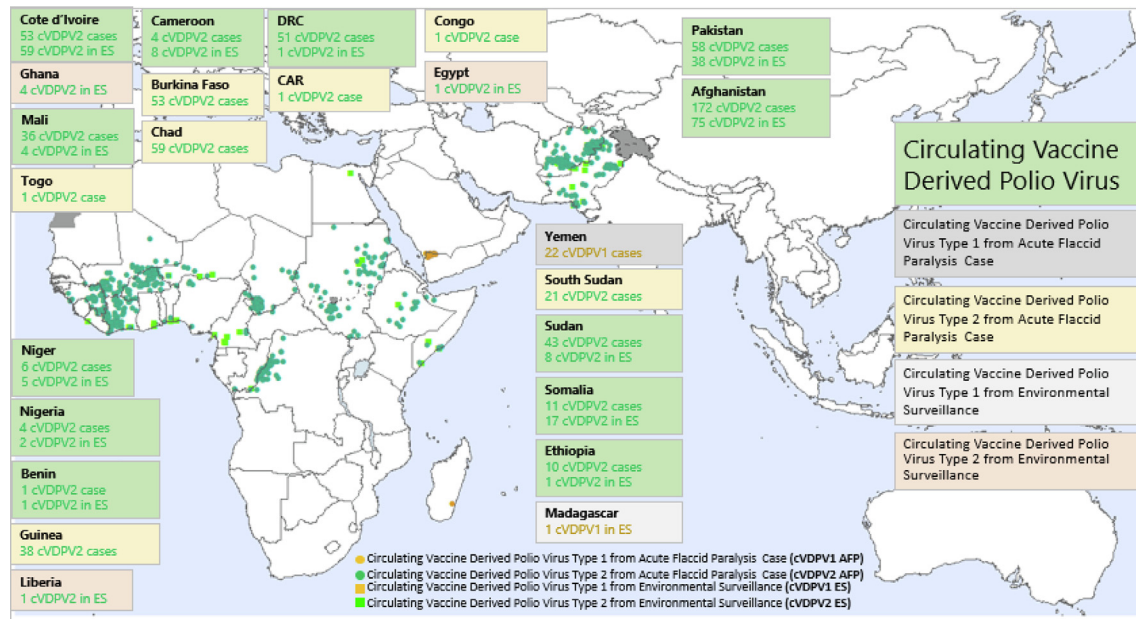
Even prior to the onset of the COVID-19 pandemic, poliovirus type 2 mucosal immunity was already estimated to be low outside of areas that had received mOPV2 as part of an outbreak response [16]. Modeling conducted in April-May 2020 to assess the impact of the suspension of SIAs on poliovirus transmission predicted an accelerated expansion of existing cVDPV2 outbreaks with a further risk of uncontrolled, progressive international spread into areas with low immunity and poor sanitation [17]. The delay to polio eradication efforts in Pakistan and Afghanistan was also predicted to not only lead to an exponential rise in cVDPV2 cases [18], but also precipitate a substantial increase in WPV1 transmission [19].



*One planned Bivalent Oral Poliovirus Vaccine campaign planned to include Inactivated Poliovirus Vaccine for a proportion of the target children

Source: WHO/POLIS

Fig. 4. Number of polio vaccine supplemental immunization activities (SIAs) postponed by WHO region or sub-region; March-May 2020.



Data in WHO HQ as of 31 August 2021

Fig. 5. Circulating Vaccine Derived Poliovirus positive isolates with Onset/Collection, 30 March –29 September 2020.

Additional modeling was conducted to address initial concerns that resuming SIAs might precipitate community spread of COVID-19. Models indicated that fixed post and door-to-door campaigns targeting children under age 5 could have a small, transient effect on the transmission of severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) depending on the community setting, but these risks could be substantially reduced by mitigation measures such as deployment of volunteers and health workers local to the vicinities and appropriate use of personal protective equipment (PPE) by vaccinators [20].

2.3.2. Epidemiologic data

From January–March 2020, AFP surveillance in the remaining endemic countries of Afghanistan and Pakistan detected 54 WPV1 cases (compared to 12 for the same time in 2019) and ES confirmed additional widespread transmission in both countries [1]. On 31 March 2020 at the start of the COVID-19 pandemic, ongoing cVDPV2 outbreaks were already identified in 19 countries (primarily in Africa, but also in Afghanistan, China, Pakistan, Malaysia, and the Philippines) along with cVDPV1 outbreaks in four countries (Indonesia, Malaysia, Myanmar, and the Philippines), and a cVDPV3 outbreak in Somalia [21].

Despite the documented declines in surveillance sensitivity concomitant with the spread of COVID-19 noted above, extensive poliovirus transmission continued to be detected in multiple countries during the 6-month period from April–September 2020 [22]. Although the African region was officially certified as free from WPV on 25 August 2020, cVDPV2 circulation persisted widely on the continent as well as in Afghanistan and Pakistan which both also faced concurrent WPV1 transmission (see Fig. 5). As poliovirus transmission models used by GPEI predicted, cVDPV2 transmission not only continued in previously detected outbreak areas, but also expanded extensively outside the response zones during the suspension of SIAs.

3. Resumption Phase: mitigation and response

Even during the emergency phase of the pandemic (March–June 2020) when GPEI initially halted SIA implementation and endorsed

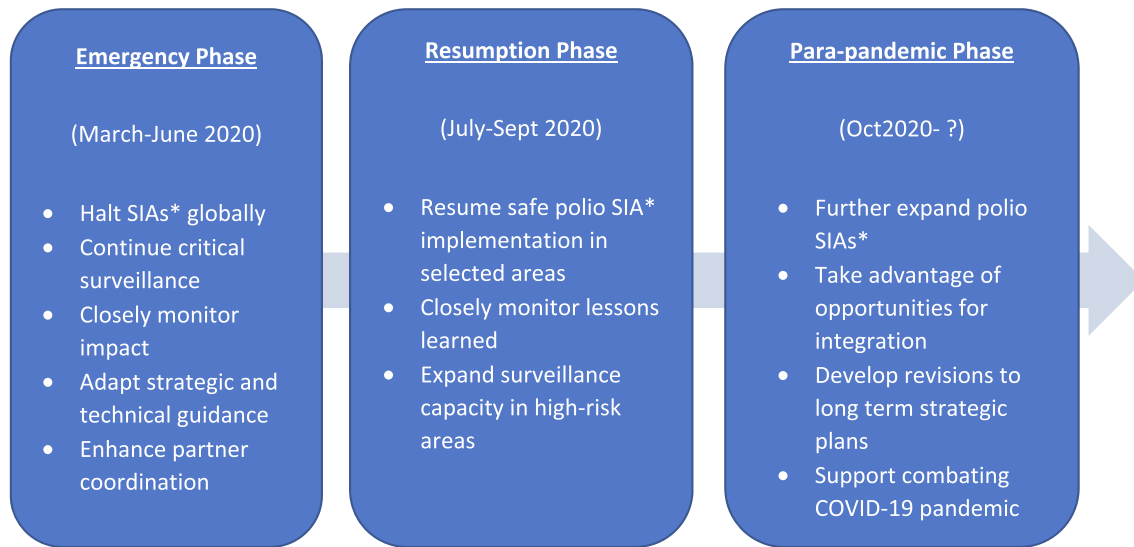
support for the COVID-19 response, the programme initiated adaptive measures designed to ensure the continuity of essential polio eradication efforts and optimize the potential for the programme's resumption of full-scale eradication activities (July–September 2020) (See Fig. 6).

Mitigation measures to adapt to COVID-19 included: extensive impact monitoring and risk analysis, ongoing revisions to strategic guidance, enhanced coordination with the EPI and other essential health services, and development of new technical guidance to accommodate COVID-19 imposed requirements.

3.1. Strategic guidance and coordination

Based on risk models and the epidemiologic evidence of intensifying poliovirus transmission, on 21 May the GPEI issued revised guidance for regional and country polio eradication programmes [23]. While endorsing continued GPEI support to local COVID-19 response efforts, key updated recommendations included: 1) all countries with active polio transmission should immediately restart SIA planning and resume implementation after risk-benefit analysis ensured the benefits of carrying out the activity outweigh the risks of COVID-19 transmission among frontline health workers and communities; 2) all non-endemic and non-outbreak countries should continue the suspension of preventive polio campaigns until the local situation permits safe and effective resumption; and 3) countries should use the opportunity of restarted polio SIAs to explore opportunities to include the delivery of COVID-19 response related materials or even other health services and vaccines.

This strategic update on resuming SIAs was issued concurrently with a broader WHO framework to assist national decision makers in conducting the recommended risk-benefit analysis prior to implementing any mass vaccination campaigns during the pandemic [24]. This guidance was a product of collaboration among GPEI and EPI partners and reflected an effort to enhance coordination of global and regional efforts to actively support all immunization activities in the COVID-19 context through joint representation on management groups, information sharing, and consistent messaging.



* Supplemental Immunization Activity

Fig. 6. Phases and priority program activities of GPEI adaptation to COVID-19 Pandemic (March-October 2020 and beyond).

3.2. Maintaining and enhancing poliovirus surveillance

The two key principles for poliovirus surveillance since the start of the pandemic have been: 1) maintain at least minimum surveillance sensitivity; and 2) focus on staff care and safety. In May 2020, the GPEI issued detailed guidance to country polio surveillance teams on how to support COVID-19 surveillance along with specific recommendations on how to prioritize polio sample shipments and processing and to safely continue case investigations and community-based polio surveillance [25]. Country level polio teams organized AFP-COVID-19 training sessions along with local physicians and public health workers, initiated innovative measures to work around challenges to specimen transport, and developed specific plans for restoration of surveillance to at least pre-COVID-19 levels wherever required. Due in large part to mitigation measures taken by the GPEI, reported AFP cases gradually increased (see Fig. 2). For the key regions of AFR and EMR, September 2020 was the beginning of a positive trend towards pre-pandemic levels for both AFP reporting and ES stool shipments [11].

3.3. Resumption of polio vaccine delivery

Resumption of polio SIAs required addressing technical, operational, and political dimensions of the unprecedented situation generated by the COVID-19 pandemic. The GPEI provided detailed technical guidance to country polio programmes regarding the necessary adaptations in planning campaigns, selecting and training staff, and delivering vaccines to maximize safety for both front line workers and communities in either house-to-house or fixed site activities [26]. While the specific infection prevention and control (IPC) recommendations differed somewhat according to the assessed degree of local COVID-19 transmission and adopted delivery strategy, the guidelines highlighted broad communication messages necessary in all countries to address the substantial challenges generated by the ‘infodemic’ of misinformation and rumors surrounding COVID-19.

The evolving poliovirus transmission also necessitated adjustments to the operational scope of the campaign plans which had been developed prior to the COVID-19 induced hiatus. In addition to epidemiologic evidence of new poliovirus detections, information provided by updated risk assessments and real time predictive

models of the spread of cVDPV2 transmission were available to determine the scale required by the resumed SIAs to halt new outbreaks [17]. These revisions in SIA plans in multiple areas around the world consequently generated extra challenges for global polio vaccine supply management as well as new demands on staff and financial resources. In addition to the increased operational costs for vaccine and delivery incurred by the expanded scope of campaigns, all SIA budgets were augmented by a further 10% in order to cover COVID-19-related IPC costs [27].

The near universal disruptions across all essential health services, coupled with the pressure that most national governments faced to prioritize their COVID-19 response, highlighted the critical importance of coordination and advocacy to the successful resumption of local polio eradication activities. GPEI infrastructure was already instrumental in the pandemic response in many countries, but all national polio programmes were required to engage closely with their relevant COVID-19 task force to ensure polio SIAs fit into national priorities for allocation of PPE and other resources as governments faced the daunting task of resuming multiple critical public health programmes. The call to improve overall efficiency, effectiveness, and speed of delivery for all essential health services through better public health programme coordination intensified as countries faced the burden of simultaneously intensifying multiple public health programmes adversely affected in the COVID-19 pandemic [28]. Proposed interventions included implementing multi-antigen SIAs as well as expanding joint delivery of multiple services (e.g., nutrition, water and sanitation) or commodities (e.g., bed nets) through integrated campaigns [29].

Full resumption of routine EPI delivery and SIAs targeted to control outbreaks of other VPDs such as measles faced many of the same challenges as GPEI and its polio eradication efforts, yet extensive disruptions to EPI observed early in the pandemic appear to have at least been partially mitigated by early 2021. A follow-up WHO survey of national ministries of health in April 2021 found that only 16 of 33 (48%) of AFR countries and 5 of 19 (24%) of EMR countries reported disruptions to immunization services due to COVID-19 compared to 86% and 67% for the respective regions in May 2020 [30]. The innovative delivery approaches used to catch-up routine vaccinations among children missed due to COVID-19 disruptions also provided essential contributions to increasing polio immunity, especially for type 2 [31].

3.3.1. Status of SIA resumptions (through end September 2020)

The GPEI suspension of polio SIAs in mid-March 2020 immediately impacted five bOPV SIAs already planned in Afghanistan and Pakistan through June 2020 targeted to stop the endemic WPV1 transmission. Both countries re-started their eradication campaigns after a six-months hiatus in mid-September 2020. Fourteen countries (including Pakistan) also suspended a total of 27 cVDPV2 outbreak response SIAs which had been planned for implementation between late March to early June 2020 [12]. After extensive planning by regional and country teams, these activities were re-started in early July 2020 in Burkina Faso and Angola, and by the end of September 2020 a total of 10 countries (7 in AFR, 2 in EMR, and 1 in the Western Pacific region) of the 14 which postponed SIAs had implemented at least one cVDPV2 outbreak response vaccination campaign with mOPV2 after delays ranging from 4 to 6 months [32].

Despite logistical challenges, several countries managed to deliver other services or commodities as part of resuming polio vaccine SIAs [33]. Along with mOPV2, vaccinators in Pakistan, Afghanistan, and Niger distributed commodities such as soap, masks, vitamin A, and deworming tablets. Somalia, Angola, and the Philippines conducted integrated campaigns delivering a combination of MR, bOPV, IPV, vitamin A, and deworming tablets through fixed outreach sites and health facilities. Additional plans for combining MR or other vaccines with bOPV as part of preventive SIAs in several countries were suspended as of October 2020 due to both financial constraints and competing priorities associated with the pandemic.

Preliminary monitoring data demonstrated inconsistent program performance and widespread gaps in vaccination coverage following the restart of SIAs in July 2020 [32]. Some countries (e.g., Cameroon and Mali) struggled to achieve even 50% coverage reportedly due to community concerns about COVID-19. However, determining the direct impact of COVID-19 on SIA quality is problematic due to variable national capacities, local circumstances, and prior experience implementing campaigns. In any case, coverage improved in subsequent rounds in most countries demonstrating that quality house-to-house campaigns are implementable in the current COVID-19 environment by adjusting strategies to the local context and rigorously utilizing field guidance on ensuring the safety of vaccinators and communities [34]. Field monitors routinely described adequate supplies of PPE and general compliance with IPC measures.

Key lessons reported by country polio programmes include: 1) fully coordinate all SIA planning and implementation with national and local COVID-19 task forces; 2) ensure high quality pre-campaign briefings on IPC measures with both front line workers and community leaders; 3) use the same local residents for pre-campaign community mobilization and for vaccination both to reduce risk of COVID-19 exposure and to further community acceptance; 4) provide attentive supportive supervision and in-process monitoring to ensure timely identification of gaps and mid-course corrections; 5) establish strong tracking systems to rapidly detect and respond to rumors or misinformation, especially within the COVID-19 context; and 6) SIA campaigns in the COVID environment are more expensive due to IPC-associated costs [33].

4. Para-pandemic phase: continued challenges and opportunities during the COVID-19 pandemic (October 2020–September 2021 and beyond)

In adapting to the ongoing threats to global polio eradication posed by the persistent challenges presented by the COVID-19 pandemic, the priorities for the GPEI for the *para*-pandemic period starting in October 2020 have been: 1) to catchup and expand polio

vaccination activities, including the introduction of novel OPV2 (nOPV2)³; 2) to take advantage of opportunities for integrating polio vaccination and surveillance activities with EPI and other essential health services; 3) to identify further revisions to medium and long-term strategies and tactics required for adapting to the dynamic situation of the COVID-19 pandemic; and 4) to continue providing critical support to protect communities from COVID-19 anywhere that polio resources are available (See Fig. 6). Countries were able to conduct all the previously postponed cVDPV2 outbreak response SIAs by May 2021 [11]. Including the postponed SIAs and additional responses to new cVDPV2 outbreaks, the GPEI conducted 62 SIAs from October 2020 through end August 2021 [34]. However, stopping uncontrolled, progressive international spread of cVDPV2 requires faster, higher quality, and geographically wider outbreak response SIAs compared to the pre-pandemic era. In spite of the full resumption of SIAs, cVDPV2 transmission has continued throughout sub-Saharan Africa, Afghanistan, and Pakistan [34]. All of these countries burdened by poliovirus transmission face concurrent COVID transmission and struggle to vaccinate their populations with COVID vaccines [2]. While Pakistan and Afghanistan continue to experience extensive cVDPV transmission, both countries have managed to significantly curtail WPV1 transmission in 2021 through a combination of bOPV and trivalent oral polio vaccine (tOPV) SIAs.⁴ Additional rounds of bOPV have been used to address scattered cVDPV1 or cVDPV3 outbreaks in other countries, but as of September 2021, bOPV SIAs planned as preventive measures to bolster immunity for types 1 and 3 remain on hold in six countries and planned catch-up IPV campaigns have yet to be conducted in 13 countries [11].

Enhancing opportunities for integration are integral to future eradication efforts and have been prioritized in the newly revised GPEI Polio Eradication Strategy for 2022–2026 [35]. While prior initiatives to integrate activities between the polio and EPI activities at global, regional, and country levels have been primarily sporadic and ad hoc, the widespread disruptions to both programmes caused by COVID-19 have precipitated a more urgent need for coordinated approaches. In addition to the impact on polio eradication outlined above, WHO and UNICEF estimate that in spite of decreased disruptions to delivering EPI services, 23 million children missed out on basic vaccines through routine immunization services in 2020 – 3.7 million more than in 2019 [36]. Faced with addressing this gap in combating childhood VPDs and ongoing poliovirus transmission stakeholders from both the GPEI and EPI programmes have jointly identified specific activities for a wide range of programme areas that represent opportunities for integrated actions covering service delivery, surveillance, and outbreak response in the context of the COVID-19 pandemic [37].

A key challenge for GPEI and EPI partners at the global, regional, and national levels will be to not only integrate efforts targeting children vulnerable to polio and other VPDs, but also to simultaneously balance competing demands on staff and infrastructure to assist with the distribution and delivery of COVID vaccines primarily for adults. By September 2021 countries in AFR and EMR have provided COVID vaccination to only a minority of their eligible populations [2]. However, as vaccines become more available in these regions and COVID cases continue, countries may understandably prioritize stopping the pandemic which could jeopardize national and community support for other public health initiatives and put further stress on polio eradication. Lessons learned by the

³ nOPV2, developed in order to reduce the risk of cVDPV2 associated with mOPV2, was first introduced under Emergency Use Listing (EUL) in March 2021 and will gradually replace mOPV2 if its efficacy and safety are confirmed.

⁴ In April-May 2016 tOPV was withdrawn in a globally synchronized switch to bOPV for both routine and outbreak response. However, in April 2020, the Strategic Advisory Group of Experts on Immunization Polio Working Group endorsed the targeted re-introduction of tOPV for countries with simultaneous transmission of multiple polio types.

GPEI during the immediate resumption of cVDPV2 outbreak response SIAs may provide critical inputs in adapting to the diversions brought about by COVID-19.

5. Conclusion

The sudden onset of COVID-19 adversely impacted GPEI programme implementation across the globe. However, the programme initiated multiple steps to mitigate these impacts and demonstrated that delivering vaccines and conducting polio surveillance during the pandemic is achievable, albeit with significant operational modifications. The extent of future adaptations required by the GPEI as well as the length of the COVID-19 pandemic remains uncertain. Nevertheless, through their inputs to the overall pandemic response and resilience in resuming polio activities, GPEI staff, especially at the field level, have again demonstrated their valuable contribution to bolstering national public health capacities and addressing additional challenges to stopping poliovirus transmission. Sustaining these capacities along with achieving polio eradication will require continued commitment, flexible planning, and the ongoing focus of the entire GPEI infrastructure.

Funding

This research did not receive any specific grant from funding agencies in the public, commercial, or not-for-profit sectors.

CRediT authorship contribution statement

Brent Burkholder: Conceptualization, Investigation, Project administration, Formal analysis, Writing – original draft, Writing – review & editing, Visualization. **Zubair Wadood:** Conceptualization, Investigation, Formal analysis, Writing – review & editing, Visualization. **Ahmed Kassem:** Conceptualization, Writing – review & editing. **Derek Ehrhardt:** Conceptualization, Writing – review & editing. **Delayo Zomahoun:** Conceptualization, Investigation, Formal analysis, Writing – review & editing, Visualization.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Acknowledgements

We wish to acknowledge the dedication and extensive efforts of frontline polio and immunization workers who have persevered despite extensive personal and programmatic challenges imposed by the COVID-19 pandemic. Additionally, we are grateful to Melissa Corkum, Hemant Shukla, and Muhammad Obaid-ul Islam Butt for contributing valuable first-hand operational insights and comments to the article. Ajay Goel provided important surveillance and SIA data.

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