





RESEARCH PAPER



## Detection of vaccine-derived poliovirus circulation by environmental surveillance in the absence of clinical cases

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### ABSTRACT

**Background:** On August 25, 2019, the Noguchi Memorial Institute for Medical Research notified the confirmation of a circulating-vaccine-derived poliovirus type-2 (cVDPV2) from the Agbogbloshie environmental surveillance (AES) site, in the Greater Accra Region. A field investigation of the outbreak was conducted to describe the results of epidemiological and laboratory investigations, and control efforts.

**Methods:** We conducted a descriptive investigation, records review, and active-case-search. Caregivers were interviewed on the vaccination status of their children; knowledge, attitude, and practices on polio prevention; water, sanitation and hygiene practices, and health-seeking behaviors. Stool from healthy children <5 y and sewage samples were taken for laboratory diagnosis.

**Results:** cVDPV2 genetically similar to the cVDPV2 diagnosed recently in the Northern Region of Ghana and Nigeria was identified. 2019 half-year coverage of OPV and IPV was 22%. Fully immunized children were 49% (29/59). Most health workers (70%) had a fair knowledge of polio and acute flaccid paralysis (AFP). Forty-six percent of care-givers admitted to using the large drain linked to the site where the cVDPV2 was isolated as their place of convenience and disposing of the fecal matter of their children. No AFP case was identified. Stool samples from 40 healthy children yielded non-polio enteroviruses while 75% (3/4) of the additional sewage samples yielded cVDPV2.

**Conclusion:** cVDPV2 was isolated from the AES site. No AFP or poliovirus was identified from healthy children. There is a need to improve health workers' knowledge on AFP and to address the dire sanitation conditions in the Agbogbloshie market and its environs.

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## Introduction

Poliomyelitis, which is caused by poliovirus serotypes 1, 2, and 3 is a highly infectious viral disease that can have crippling effects. It mainly affects children who are less than 5 y of age. According to Robert,<sup>1</sup> in one out of 200 polio infections in developing countries, paralytic polio is observed, while fatality is normally observed in 5–10% of paralytic polio cases. Low immunization rates, poor sanitation, and high population densities are the major risk factors for polio. The virus is transmitted by person-to-person spread mainly through the fecal-oral route or, less frequently, by a common vehicle (for example, contaminated water or food) and multiplies in the intestine. Polio, can only be prevented as it has no cure; and the polio vaccine, given multiple times, can protect a child for life. The key advantages of oral polio vaccine (OPV) are ease of administration and efficient induction of mucosal immunity, thereby limiting poliovirus shedding and person-to-person transmission.<sup>2</sup>

Since the launch of the Global Polio Eradication Initiative (GPEI), paralytic cases associated with wild poliovirus (WPV) have fallen from ~350,000 in 1988 to 33 reported cases in 2018. Wild polio type 2 (WPV2) was last detected in 1999, WPV3 in 2012, and WPV1 appeared to be localized in Pakistan and Afghanistan in 2017.<sup>3–5</sup>

Global efforts to immunize children with the oral polio vaccine (OPV) have reduced wild poliovirus cases by 99.9% since 1988. The vaccine is safe and effective, and interrupts the person-to-person spread of polio. However, on rare occasions, and only in under-immunized populations, the live weakened virus originally contained in OPV can mutate into cVDPV, and affect children as well as their direct contacts. Eight countries (the Democratic Republic of Congo [DRC], Indonesia, Mozambique, Niger, Nigeria, Papua New Guinea, Somalia, and Syria) reported 210 cVDPV cases within 2017–2019 (as of May 3).<sup>6</sup>

VDPVs are operationally defined as OPV-related isolates having greater than 1% nucleotide (nt) sequence divergence from the parental OPV strain in the ~900-nt region encoding the major capsid surface protein, VP1. When there is clear evidence of transmission beyond close contacts, they are categorized as circulating (cVDPVs). The risk of cVDPV emergence appears to be highest for the Sabin type 2 (Sabin 2) OPV strain, particularly in areas with high densities of nonimmune persons, poor sanitation, and tropical or subtropical areas.<sup>7,8</sup>

The most common clinical manifestation of paralytic poliomyelitis is the syndrome of acute flaccid paralysis (AFP). In 1996, active surveillance for AFP cases was established with full laboratory support to help in detecting poliovirus in Ghana.

Cases of wild poliovirus increased from two (2) in 1996 to twenty-three (23) in 1998 and reduced to one in 1999 when the last indigenous strain was seen. The country has experienced two major wild poliovirus outbreaks, in 2003 and 2008. Since the last case of wild poliovirus in 2008, continuous supplementary immunization activities (SIAs) coupled with quality acute flaccid paralysis (AFP) surveillance with the appropriate documentation to the Regional Certification Committee had declared Ghana a polio-free country in 2015.<sup>9</sup> Despite the good in the impending global eradication, there persist few areas of inherent transmission in Africa (Nigeria) and Asia. A danger of importing wild poliovirus to countries that are almost polio-free therefore still exists.<sup>10</sup> Ghana switched from tOPV to bOPV in April 2016 (synchronized globally) as part of the phased withdrawal of OPV. IPV was introduced in June 2018.

As part of international best practice to ensure complete surveillance of all forms of poliovirus, Environmental surveillance (ES) has been instituted in many countries including Ghana, which piloted ES in 2016 and fully established it in 2018. In July 2019, a circulating vaccine-derived poliovirus was confirmed in an environmental surveillance sample from the Tamale Koblimaghu drain in the Tamale Metro of the Northern Region of Ghana. Subsequently, cVDPV2 was isolated from an acute flaccid paralysis (AFP) case in Ando-Nyamanu, Chereponi District, Northern Region, bordering Togo. The sample tested positive for cVDPV2 on August 17th, 2019.<sup>11</sup>

On August 25, 2019, the Noguchi Memorial Institute for Medical Research (NMIMR) notified the confirmation of cVDPVs from the Agbogbloshie environmental surveillance site, in the Greater Accra Region (Figure 1). The present report describes the results of epidemiological and laboratory investigations, and control efforts regarding the cVDPVs outbreak.

## Methods

### Study setting

The field investigation was conducted from 27th to August 30th, 2019, in Agbogbloshie following the confirmation of cVDPV2. Agbogbloshie is a nickname for a commercial district on the Korle Lagoon of the Odaw River, near the center of Accra, Ghana's capital city. It is located in the Ashiedu Keteke Sub Metro of the Greater Accra Region with a population of about 146,000 on Latitude 5.5508°/Longitude -2.134°. The Agbogbloshie area houses one of the largest e-waste dumps in sub-Saharan Africa, processing an estimated 129,000 tonnes of e-waste each year. Roughly 40,000 Ghanaians inhabit the area, most of whom are migrants from rural areas. Concerns about human health and the environment of Agbogbloshie continue to be raised as the area remains heavily polluted. Children who should attend school often spend every evening and weekend processing waste and searching for metals. There is lack of water and sanitation in the wooden shacks that make up the dwellings at Agbogbloshie.<sup>12</sup> There are



Figure 1. Map of Ghana, showing Greater Accra, Ashiedu Keteke where Agbogbloshie is located.

two (2) major Government clinics (Old Fadama and Ayalolo) with approximately 20 health workers, and a few private health facilities found in the vicinity. The majority of people in the Sub metro seek health care from health facilities of the Ghana Health Service which has the Ministry of Health as its policy-making body. The Ghanaian healthcare system has five levels of providers: Community-Based Health Planning and Services (CHPS) (the first level of care), health centers, district hospitals, regional hospitals, and tertiary hospitals. Routine polio immunization program for children includes four doses of live attenuated oral polio vaccine (OPV). Children receive their first vaccination (OPV0) at birth. The remaining three doses (OPV1, OPV2, and OPV3) are given at 6 weeks, , and 14 weeks after birth, respectively. With the new immunization schedule after the switch from trivalent oral polio vaccine (tOPV) to bivalent oral polio vaccine (bOPV), children receive bOPV for OPV0, OPV1 OPV2, OPV3 and inactivated polio vaccine (IPV). Children, less than 5 y of age are given two doses of OPV during the national immunization campaigns until the age of five. Generally, the administration coverage of the oral polio vaccine has attained higher than the expected target of 90% in the Greater Accra Region.

Ghana commenced Environmental Surveillance in 2016 and it is principally driven by the World Health Organization (WHO), the National Polio Laboratory, and the Ghana Health Service. There are 10 sewage collection sites which include Agbobloshie. Sewage samples are collected once in a month and processed by Grab method according to World Health Organization guidelines on environmental surveillance.<sup>13</sup>

### **Study design**

We conducted a descriptive investigation, records review and an active case search. We interviewed the Sub metro staff members: Director of Health Services, Disease Control Officer (DCO), Public Health Nurse, the Hospital Management Team of Princess Marie Louise (PML) Children's Hospital, and the Environmental Health Officer to obtain information on the outbreak. Based on the information gathered we conducted an active case search and interviews in the health facilities and communities for AFP cases. We defined a suspected polio case as any child under 15 y of age with acute flaccid paralysis or any person with paralytic illness at any age in whom the clinician suspects poliomyelitis at Agbobloshie, located in the Ashiedu Keteke Sub Metro of the Greater Accra Region between January to August 28, 2019; and a confirmed case was defined as a suspected case with virus isolation in stool.

The investigation team comprised of residents from the Ghana Field Epidemiology and Laboratory Training Programme (GFELTP) and Ghana Health Service (GHS). WHO and CDC staff members were available to provide technical support.

### **At health directorate level**

The AFP surveillance and immunization records were reviewed at the Greater Accra Regional Headquarters, Accra

Metro and Ashiedu Keteke Sub-Metro Health Directorates, to assess preparedness, AFP surveillance and polio vaccination coverage in routine and supplementary immunization activities (SIAs). Vaccine management capacity, equipment, and records were also assessed.

### **At health facility level**

OPD and inpatient registers from January to August 28, 2019, were reviewed at Princess Marie Louise (PML) Children's Hospital to identify reported and potentially missed AFP cases. Knowledge of health staff on AFP surveillance and case definitions were assessed through interviews with nurses and disease surveillance officers. Reporting and data management practices were also assessed. The PML Children's Hospital was prioritized because it is a referral facility for pediatric care and is the first point of call for parents seeking healthcare for their wards in the sub-metro.

### **At community level**

The ES site is located within the Agbobloshie market area. One side of the drain is blocked off by a wall separating different sections of the market while the other side is open. The site was visited and areas upstream the sample collection site were mapped out. Considering that the market was a converging point for people from various parts of the country and beyond, a rapid mobility survey of children in the market was conducted. Guardians of 56 children under 5 y were interviewed to assess the travel history of the children.

The Agbobloshie market area also has some residential facilities – usually squatters – dispersed throughout the market with public toilets that open into the drain. A total of 59 households upstream the Agbobloshie ES site with children less than 5 y were involved in a household survey. Mothers were interviewed on the vaccination status of their children and their vaccination records reviewed. Furthermore, 39 caregivers in the households visited were interviewed on their knowledge, attitude and practices on polio prevention; water, sanitation and hygiene (WASH) practices, and their health-seeking behaviors.

Active case search for acute flaccid paralysis was conducted in a total of 344 households within the market area, upstream the ES site.

### **Environmental survey**

An environmental survey of households of the inhabitants of Agbobloshie was undertaken. Their sources of water supply were inspected, principally observing activities around the area, the drainage system, sewage lines, and general sanitation.

### **Laboratory investigations**

The laboratory team identified four sites upstream of the drain and collected sewage samples from these sites for testing in the laboratory. Among the households visited, stool samples were collected from 40 healthy children less than 5 y and transported to the Noguchi Memorial Institute for Medical Research (NMIMR) for laboratory investigations. The 2-phase separation method was used for sewage sample concentration with

quality control ensured by the regional reference laboratory and inoculated on RD and L20B cell lines for virus isolation and intratypic differentiation (ITD) of the isolates by real-time RT-PCR (rRT-PCR) amplification followed by sequencing of the VP1 region according to standard WHO protocol.<sup>14–16</sup>

### Data analysis

This was an outbreak that involved a single event and was described appropriately. Data on Rapid community immunization survey were entered into Epi Info software version 3.3 for data cleaning and analysis. We performed descriptive analysis of the outbreak data. Univariate analyses were expressed as frequency distributions and percentages. Immunization coverage was calculated as the proportion of vaccinated individuals among the target population. The drop-out rate (%) was calculated as a percentage of the number of dropouts by the cumulative total for the first dose.

### Results

On August 25, 2019, Noguchi Memorial Institute for Medical Research confirmed cVDPV2 from sewage samples collected from the Agboghloshie environmental surveillance site. From one ES collection, all five flasks of L20B (F1–5) and one RD flask (F6) yielded PV2. Genetic sequencing of the isolates indicated that the viruses differed by 26–28 nucleotides from Sabin 2 and differed by 6–8 nucleotides from the closest matching sequence of (VDPV2 lineage) as shown in Table 1. This virus was genetically similar to that of the cVDPV2 in Tamale and Chereponi outbreaks in the Northern part of Ghana. The same viral genotype has been linked to an outbreak in Nigeria.

### Immunization performance

The regional OPV3 coverage administrative data was below 90% from 2015, but after the population re-basing by the Ghana Statistical Service in 2018, which affected data from 2015, coverage appears to be high (Table 2). The region has consistently recorded negative dropout rates over the years. There was a regional disease control and prevention micro plan for 2019. However, the plan does not elaborate plans and strategies for improvement in routine immunization coverage. The last NID in the region was a tOPV campaign in October 2015 with coverage of 99.3% (Table 3). Vaccination coverages have been particularly low over the past 5 y at the Sub-Metro level, where

Agboghloshie is located, with the highest OPV3 coverage of 71.2% in 2016 and less than 60% in 2017 and 2018. The current half-year coverage for both OPV3 and IPV was 22.1%.

### Rapid community immunization survey

A total of 59 children under 5 y were involved in the rapid coverage survey out of which 28 (47%) were males and 19 (32%) were children under 1 y. A review of vaccination records indicated 29 (49%) were fully immunized for age. Ninety percent (90%) of the caregivers sampled have heard about polio and could give an example of one symptom. However, knowledge of the prevention, mode of transmission, and the schedule were lacking for all respondents. Most caregivers did not know which diseases are prevented by the vaccines administered to their children.

Out of the 37 parents interviewed, 17 (46%) admitted to using the large drain linked to the site where the cVDPV2 was isolated as their place of convenience or for disposal of the fecal matter of their children after they use the chamber pot. Sixteen (43%) of these people used pit latrines in the community but switched to the open drain when the pit latrine got full. Only five (14%) had a water closet with well-constructed septic tanks. It is acceptable and normal for children in the community to use the drainage as their place of convenience; hence, the presence of the team at the site did not put any fear in them.

Almost 90% (49/56) children under 5 y found in the market spend more than 3 d each week in the market. It was noted that foreigners, including Togolese, Nigerians and other West African Sub-Region nationals also traded in the market. The Child Welfare Clinic points are also not easily accessible, a bit far-flung for people who are too busy with focus on business to see and be prompted to attend. And the big size of the market makes it impossible for the few nurses who provide service at the child welfare clinics to go round announcing their presence.

### Environmental health assessment

The ES site is located within the Agboghloshie market area. One side of the drain is blocked off by a wall separating different sections of the market while the other side is open. The drain is choked with litter, from plastics to organic waste. The drain splits a few meters upstream at the sample collection point. It is partially open within the market area while the greater part that goes to the commercial center is covered. There are several public toilets in the market with outlets going into the drain.

**Table 1.** Differences between the Agboghloshie strains, Sabin 2 reference strain, the cVDPV2 ES from Tamale Metro, and AFP from Chereponi.

Agboghloshie VDPV STRAIN	Nucleotide changes		
	Nucleotide difference with		
	Sabin 2 ref strain	ENV-GHA-NOR-TAM-KOB-19-007	GHA-NOR-CHE-19-004
ENV-GHA-GAR-ASK-AGB-19-009F1	26	7	5
ENV-GHA-GAR-ASK-AGB-19-009F2	27	7	5
ENV-GHA-GAR-ASK-AGB-19-009F3	27	8	6
ENV-GHA-GAR-ASK-AGB-19-009F4	28	9	7
ENV-GHA-GAR-ASK-AGB-19-009F5	27	8	6
ENV-GHA-GAR-ASK-AGB-19-009F6	28	8	7

Reference strain: Sabin2, Tamale strain: ENV-GHA-NOR-TAM-19-007, Chereponi strain: ENV-GHA-NOR-CHE-19-004

**Table 2.** Greater Accra Region OPV routine immunization coverage (%) 2015–2019.

Antigen	Greater Accra region immunization coverage (%) 2015–2019				
	Year				
	2015	2016	2017	2018	2019
Target	180289	184545	188876	193268	197723
OPV1	147116	153289	151088	174197	88619
OPV3	156506	164186	167170	188884	92062
IPV		IPV introduced in June 2018		91090	91070
OPV 1 (%)	81.6	83.1	80.0	90.1	44.8
OPV 3 (%)	86.8	89.0	88.5	97.7	46.6
IPV (%)		IPV introduced in June 2018		47.1	46.1
OPV1/3 (DOR)(%)	–6.3	–7.1	–10.6	–8.4	–3.9
Un-immunized	23783	20359	21706	4384	

**Table 3.** NID, Greater Accra Region, 2012–2015.

Greater Accra Region NID, 2012 to 2015						
Year	Date	Type	Target	No. Vaccinated	Coverage	Vaccine Type
2012	22–24/03/2012	NID	823900	891289	108.2	tOPV
2013	06–08/06/2013	NID1				tOPV
2013	24–26/10/2013	NID2	823900	875536	106.0	tOPV
2014	18–20/10/2014	NID1				tOPV
2014	30/10-01/11/2014	NID2	875782	923010	105.4	tOPV
2015	22–24/10/2015	SNID	699843	694777	99.3	tOPV

Whereas children defecate directly into the drain, adults sometimes defecate into chamber pots and/or black polytene bag and throw the feces into the drain. During the day time, many people come to the market and commercial center for business and in the process discharge their liquid and solid wastes into the drain. The waste from four (4) big markets in the Accra Metropolis, namely Makola, Kantamanto, Okaishie, and Agbobloshie, is disposed of into the Agbobloshie drain.

#### **Assessment of AFP surveillance system at Agbobloshie and environs**

Besides the focal persons (FP), most health workers (70%) interviewed had a fair knowledge of the AFP case definitions. At least one FP reported organizing training for his colleagues. There were posters of simplified case definitions at the facilities visited. FPs had a good understanding of appropriate sample taking, packaging and transportation, and stool adequacy, but the same cannot be said of other health workers. The PML children's hospital has identified and reported one AFP case in 2019, while the Sub-Metro has identified and notified 4 cases, all through active surveillance in the communities. However, three cases identified in the communities were lost-to-follow-up at 60-d follow-up, while the last one is awaiting the 60 d to elapse. The loss to follow-ups highlights the highly mobile nature of the community members. No case of missed AFP was identified from the record review at the PML hospital.

#### **Outbreak response preparedness**

There was no evidence of a functional Public Health Emergency Management Committee (PHEMC) at the Regional level. The Public Health Epidemic Management Committee exists at the Metro and Sub-Metro levels. Members are mainly health personnel from the Metro, Red

Cross, GES (SHEP Staff) and Metro Coordinating Director and the Public Relations Officer (PRO). An action plan sighted was on cholera control from April – December 2019.

#### **Water, Sanitation and Hygiene (WASH)**

Community members mentioned the use of pipe-borne water for drinking and cooking. However, most of the houses had no standpipes but bought water from commercial suppliers. Other sources of water were wells, bottled water, and sachet water. Almost all the caregivers (80%) mentioned they wash their hands with soap under running water. Those who washed their hands mentioned they wash after using the toilet, before and after eating. This practice was however not observed. Further probe revealed that many of the respondents wash their hands in a pool of water in a bucket or basin and not under running water as expected/claimed.

Generally, most of the houses did not have toilet facilities, and they used the public facilities which have the flush system. Twelve out of the 30 respondents use public Kumasi ventilated improve pit (KVIP) and the flush system. The community had 3 KVIPs. It was observed and reported that some of the children use chamber pots after which fecal material is directly disposed of in gutters/drains or tied in plastic bags and discarded into drains. Children above 3 y usually defecate directly into the drains. Open defecation was rampant in the community. Most people in the community dispose of their waste by dumping into gutters, depositing into approved containers situated at vantage points by the Assembly and burning.

#### **Laboratory results**

Of the 40 stool samples collected from healthy children less than 5 y of age, 15 (37.5%) showed growth on RD cells only and were classified as non-polio enteroviruses. No poliovirus was

isolated. Three of the four (75%) sewage samples collected during the outbreak response were confirmed as cVDPV2. All six flasks of samples 1 and 2 produced cVDPV2 while a single L20B flask produced cVDPV2 making a total of 13 cVDPV2. All the viruses were genetically similar to that of the cVDPV2 in Tamale and Chereponi outbreaks even though they vary in the number of nucleotides.

## Discussion

This report documents an outbreak of cVDPVs at Agbobloshie in the Ashiedu Keteke Sub metro of the Greater Accra Region of Ghana. The country was certified as poliomyelitis-free in 2015. To our knowledge, this was the third outbreak of cVDPVs in Ghana since January 2019. The emergence and circulation of VDPVs which has been absent many years and over a broad geographical area is evidence of widespread sub-optimal poliovirus immunity in some parts of Ghana. This corroborates with findings from recent investigation in the Democratic Republic of Congo (DRC).<sup>17</sup>

In September 2015, the Global Commission for the Certification of Poliomyelitis Eradication declared the worldwide eradication of WPV2, and recommended that the synchronized global “switch” from the use of tOPV to bivalent OPV (bOPV: containing polio vaccine virus types 1 and 3) should occur during April 2016.<sup>18</sup> The type 2 component of trivalent OPV (tOPV) (containing vaccine virus types 1, 2, and 3) was responsible for >90% of cVDPV cases occurring during 2006–2015. A single dose of inactivated poliovirus vaccine (IPV), which includes all three poliovirus serotypes, was introduced into routine immunization schedules in OPV-using countries to mitigate the risk of a gap in immunity to poliovirus type 2.<sup>17,19</sup> Ghana switched from the use of trivalent Oral Polio Vaccine (tOPV) to bivalent Oral Polio Vaccine (bOPV) on April 14th, 2016, without introducing IPV until June 2018 as a result of global IPV shortage.<sup>20</sup> The introduction of IPV before the change of the bOPV in 2016 to trivalent OPV (tOPV) was based on the concept of ensuring that a substantial proportion of the population would be protected against type 2 polio after the removal of the type 2 OPV. However, the world’s two producers of IPV (Bilthoven Biologicals and Sanofi) had faced problems in the production of this vaccine and therefore reported a reduction of the global supply of IPV. There are currently over two million children in Ghana who do not have protection against poliovirus type 2. This may offer some explanation to the current outbreaks of cVDPV in the country.

The immunization coverage of OPV3 in the Greater Accra Region from 2015 to 2017 was persistently below 90%. Vaccination coverage had been particularly low over the past 5 y at the Sub-metro level with the highest OPV3 coverage of 71.2% in 2016 and less than 60% in 2017 and 2018. Widespread use of live attenuated (Sabin) oral poliovirus vaccine (OPV) has resulted in marked progress toward global poliomyelitis eradication. However, in under immunized populations living in unsanitary conditions like in Agbobloshie, extensive person-to-person transmission of Sabin poliovirus can result in genetic reversion to neurovirulence and paralytic vaccine-derived poliovirus (VDPV) disease.<sup>21</sup>

It was noted that type 2 cVDPV was implicated in the current outbreak and the subsequent ones that were detected recently in the Chereponi and Tamale polio outbreak. In 1999, Ghana detected the last indigenous case of wild polio type 1. Ghana has never recorded indigenous type 2 or 3 wild polioviruses and also imported cases. Aside the confirmation from the genotyping that implicated a similar virus of cVDPV type 2 from Nigeria, the above information supports the fact that the current cVDPV was foreign.

Polio transmission is noted in areas of poor unsanitary conditions. The virus is transmitted by person-to-person spread mainly through the fecal-oral route or, less frequently, by a common vehicle (e.g. contaminated water or food) and multiplies in the intestine, from where it can invade the nervous system and can cause paralysis. The Agbobloshie area and its environs is a typical example of areas in Ghana where sanitation is poor. The environment is heavily polluted with e-waste. No proper toilet facility exists and poor housing is a major setback. Every day, one is constantly greeted with incessant and overwhelming foul smells and stench from overly choked drains and over-heaped waste bins. The inhabitants have grown accustomed to habituating with the filth and stench. Environmental contamination from protracted poliovirus circulation has played an important role in maintaining endemic conditions; in fact, poliovirus is able to survive in the environmental matrix for several months. Poliovirus has a great genetic variability, so several strains of the same serotype can be found in the feces of a human host. This fact could be relevant in epidemic situations, in which a strain intensely varied from the vaccine poliovirus is introduced into a population with low immunity levels.<sup>22,23</sup>

Isolation of cVDPV2 at Agbobloshie few weeks after confirmation of cVDPV2 at an environmental surveillance site at Koblimahigu and Chereponi from an AFP case, both in the Northern Region of Ghana coupled with their closest match is an indication of the virus moving from the north to the south of the country. Transmission of the poliovirus could have been facilitated by the business activities of transporting food crops including yam, maize, onions, and millet from the north to the south.

We found that the ES findings at Agbobloshie triggered accelerated introduction of mOPV2 to vaccinate children under 5 y of age in Greater Accra, Northern, North East, Savanna, and Upper East regions. This defines another dimension of public health intervention triggered by ES findings that helped to strengthen the AFP reporting system and timely use of information from ES to trigger public health interventions that contributed to the progress made toward the interruption of poliovirus transmission in the country.

As polio eradication becomes a reality in the near future, the use of OPV, IPV, and mOPV2 remains crucial. The first poliovaccine to be licensed was IPV. It is formalin-inactivated and effective against the virus. Formalin inactivation of IPV does modify some of the epitopes of the virus, particularly site 1 of viral types 2 and 3.

Although this modification has a limited effect on the overall neutralizing antibody response, it does affect the specificity of that response. IPV works by producing protective antibodies in the blood thus preventing the spread of poliovirus to the central nervous system. However, it induces very low-level immunity to poliovirus inside the gut. As a result, it provides individual protection against polio paralysis but only marginally reduces the spread of wild poliovirus.

Oral polio vaccine works by inducing not only serum immunity but also secretory immunity, particularly inside the intestines, the primary site for poliovirus multiplication. As well as inducing individual protection against polio, OPV limits the multiplication of wild (naturally occurring) virus inside the gut. Immunization with OPV therefore creates an effective barrier against circulation of wild poliovirus by reducing fecal excretion of the virus. However, a “helpful” outcome of immunization with OPV is the short-term shedding of vaccine virus in the stools of recently immunized children.

mOPV2 is a type 2 oral polio vaccine developed to immunize children to protect them against polio type 2 infection. The use of mOPV2 is essential to stop a type 2 poliovirus outbreak, in order to mitigate the risk of emergence of VDPV2.

There was no major limitation to the outbreak investigation except that a few of the health facilities visited had no updated facility records on AFP cases but the community search for AFP cases was very helpful to identify further cases if they were present.

In response to the outbreak, three rounds of effective mOPV2 campaigns followed by one round of IPV campaign have interrupted the transmission and VDPV2 has no longer been found in the district. There has been massive health education on polio prevention and the general need to observe adequate sanitary conditions especially in our immediate environment.

## Conclusions

Circulating vaccine-derived polioviruses were detected at Agboblshie in the Ashiedu Keteke Sub metro of the Greater Accra Region within a few weeks following its confirmation in the Northern Region. Low immunization coverage among children less than 5 y aided the transmission of the poliovirus. Many health workers had a fair idea of acute flaccid paralysis. Agboblshie with poor sanitary conditions and a high migrant population makes the environment conducive for poliovirus transmission. Outbreak response with polio immunization is highly recommended to interrupt transmission of the poliovirus. There is a need to improve health workers’ knowledge of acute flaccid paralysis surveillance. The Ministry of Sanitation, Ministry of Environment, Science, Technology, and Innovation and the Ministry of Local Government and Rural Development need to address dire sanitation conditions in the Agboblshie market and its environs.

Health workers must be given a refresher on-site training on AFP surveillance. The community needs to be engaged continuously through house to house visits and educated on the need to

ensure children complete their immunization schedules. Active AFP surveillance following the NIDs is essential to monitor the complete interruption of transmission in the Region.

## Authors’ contributions

Conceptualization and design: JKO, JKLO, SD, GB. Data collection and Statistical analysis: EO, ED, BB, EG, ME, KA, SD, GB, PA, JKLO. Drafting of the manuscript, integrity of the data, and the accuracy of the data analysis: JKLO, JKO. All authors have read and agreed to the final manuscript.

## Disclosure of potential conflicts of interest

No potential conflicts of interest were disclosed.

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## Ethical Issues

Informed consent and permission were sought from the participants before the interviews. We protected the confidentiality of participants through the use of codes. However, an ethical committee review did not apply as this was a public health response to an outbreak. A preliminary report of the outbreak was discussed with the Sub-Metro Health Administration, the Sub-Metro Assembly and the chiefs and elders of the communities.

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