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Assessment of poliovirus antibody seroprevalence in polio high risk areas of West Africa

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Abstract

We conducted a serological survey of anti-polio antibodies in polio high-risk areas of Mali, Guinea and Cote d'Ivoire to assess risk of future poliovirus outbreaks.

Random community sampling of children 6–11 and 36–48 months-old was conducted; neutralizing antibodies against poliovirus were detected using microneutralization assay.

We analysed 1059/1064 (99.5%) of enrolled children. Seroprevalence to poliovirus type 1 (PV1) across all age groups and locations ranged between 92 and 100%, for PV2 it was 77–100%, and 89–95% for PV3. PV2 seroprevalence in the younger age group in Guinea and Cote d'Ivoire was <80%. History of <4 polio vaccine doses and acute malnutrition were associated with seronegativity (OR = 2.1 CI95% = 1.5–3.1, OR = 1.8 CI95% = 1.1–3.3 respectively).

The risk of poliovirus outbreak following importation is low because of high population immunity to PV1, however, due to large cohort of PV2 seronegative children any future detection of vaccine-derived poliovirus type 2 requires urgent response to arrest rapid spread.

Keywords

Poliomyelitis; West Africa; Eradication; Seroprevalence

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Conflict of interest

All authors – no conflict of interest declared.

Disclaimer

The findings and conclusions in this report are those of the author(s) and do not necessarily represent the views of CDC and other contributing agencies.

1. Background

Despite remarkable efforts of the Global Polio Eradication Initiative (GPEI), the last foci of endemic transmission of wild poliovirus type 1 (WPV1) remain in three endemic countries (Afghanistan, Pakistan and Nigeria) [1]. As of December 20, 2017, the total of 20 paralytic poliomyelitis cases caused by WPV1 were detected in Afghanistan and Pakistan. Albeit diminished, the risk of importation of WPVs into polio-free areas persists. Outbreaks of poliomyelitis following importations of WPVs have been described in a large number of instances [2]. In West Africa, there were several such importations leading to large epidemics in the past decade [3,4]. The outbreaks following importation of WPV1 in 2008 and another importation of WPV type 3 (WPV3) in 2010 caused more than 100 paralytic poliomyelitis cases in the West African region. In both of these instances, virus had travelled large distances from Nigeria across West Africa, passing through, and establishing circulation in the area where the countries of Mali, Cote d'Ivoire and Guinea meet: the province of Kankan in Guinea, Selingue in Mali, and Korogho in Cote d'Ivoire.

In addition to wild polioviruses, the viruses emanating from the use of oral poliovirus vaccines (OPV), so called vaccine-derived polioviruses (VDPVs) may, in rare circumstances, lead to outbreaks of paralytic poliomyelitis. This was the case in Guinea in 2015 [5]. This outbreak centred in the province of Kankan, the same area of Guinea that experienced the previous WPV outbreaks.

As a response to the WPV and VDPV outbreaks, the governments of the affected countries together with GPEI partners implemented a large number of supplementary vaccination campaigns with OPV, targeting children below 5 years of age. Between 2013 and 2016, a total of 38 campaigns were conducted in these three countries; some of the campaigns were nation-wide, while others focused only on high-risk areas.

In order to reduce the risk of future VDPV2 outbreaks, a global switch from using trivalent OPV to bivalent OPV without the type 2 component was carried out in April 2016. In addition, one dose of inactivated poliovirus (IPV) vaccine was introduced in routine immunization schedules globally. This global effort was part of the Polio Eradication and Endgame Strategic Plan developed by GPEI [6].

The joint estimates by WHO and UNICEF of routine immunization coverage in 2016 with the third dose of OPV were 89% in Cote d'Ivoire, 72% in Guinea, and 74% in Mali. For the one dose of newly introduced IPV, they were 61%, 66% and 58% in Cote d'Ivoire, Guine, a and Mali, respectively [7].

Seroprevalence surveys have been used as a tool to evaluate polio program performance and to identify population immunity gaps, including routine serosurveys in Nigeria, India, Pakistan, and other areas [8–16].

To better understand the underlying population immunity and to assess the risk of future outbreaks of either WPVs or VDPVs, we conducted a population-based seroprevalence survey of anti-polio antibodies in those areas of Guinea, Mali, and Cote d'Ivoire that had experienced multiple poliovirus outbreaks in the recent past.

2. Methods

This was a community-based seroprevalence survey carried out in five study sites: two in Mali (Kenieroba and Selingue); two in Guinea (Kankan and Siguiri); and one in Cote d'Ivoire (Korhogo) (Fig. 1).

Children in each study site were randomly selected from two age groups: 6–11 months of age; and 36–48 months of age. A sample size of 120 children in each age group and each study site was calculated to be sufficient to detect, at the 95% confidence level, a seroprevalence point estimate with a precision of approximately ±5% assuming >90% seroprevalence and the proportion of nonconsenting parents <15%.

Study assistants, together with local community health workers, enumerated children residing in the catchment areas of the health centers in the study areas and selected 120 children in each age group using a simple random sampling from existing health center records. The parents or guardians of these children were invited to the health center where, after administration of the informed consent, children were enrolled. A short questionnaire on basic demographic indicators and vaccination history was taken. Vaccination history was provided either from vaccination records or by parental recall. Weight and height were measured among the children in the older age group. Chronic malnutrition was defined as height for age z-score <–2 standard deviations from mean z-score; acute malnutrition was defined as weight for height z-score <–2 standard deviations from mean z-score.

Trained phlebotomists drew 2 mL of peripheral blood. The blood specimens were allowed to clot. Serum was separated and sera were transported to Bamako, Mali, where they were stored at −20 °C until shipment to the Centers for Disease Control and Prevention (CDC) in Atlanta, USA. The sera were tested for the presence of poliovirus neutralizing antibodies at CDC using standard neutralization assays [17]. Seropositivity was defined as reciprocal titers of poliovirus neutralizing antibodies >8. Highest reported titers were 1:1448 [17].

The study was carried out in Mali in June and July 2016, in Cote d'Ivoire in November 2016 and in Guinea in December 2016 and in January 2017. Ethical clearance was obtained by the Faculty of Medicine, Pharmacy and Dentistry of Mali, the National Ethics Committee for Health Research of Guinea and the National Ethics Committee for Research of Ivory Coast approved as well as by the Ethics Review Council of the World Health Organization, Geneva, Switzerland.

3. Results

A total of 1063 children were enrolled in the survey and 1059 of the children provided analysable blood samples, including 204 from Cote d'Ivoire, 447 from Guinea, and 408 from Mali (Table 1). There were four enrolled children who provided blood samples that were insufficient for laboratory testing. We excluded these four children from the analysis.

Coverage with the third dose of Diphtheria-Pertussis-Tetanus vaccine (DTP3) is a good proxy of coverage with the third dose of OPV because the two vaccines are administered at the same time. Reported DTP3 coverage in the younger age group was significantly lower

in Mali than in the other two countries ($p < 0.001$). The proportion of children found to be acutely malnourished was significantly higher in Guinea than in the other two countries ($p < 0.001$) (Table 1).

Seroprevalence for poliovirus type 1 (PV1) ranged between 92% and 100%. It was significantly lower in the younger age group in Cote d'Ivoire than in the older age group in that country ($p < 0.001$); there were no other statistically significant differences between age groups or countries for PV1 (Fig. 2A).

Seroprevalence for poliovirus type 2 (PV2) ranged between 77% and 100%. In the younger age group, the PV2 seroprevalence was significantly higher in Mali than in the other two countries ($p < 0.001$). There were no significant differences in the older age groups (Fig. 2B). We assessed whether children born after the switch from tOPV to bOPV had different immunity against PV2 than children born before the switch. In Guinea, there were 146 enrolled children born before the official switch date (May 1, 2016) and 81 born after the switch. The PV2 seroprevalence was 86% (125/146) in those born before the switch versus 60% (49/81) in those born after the switch ($p < 0.001$). This analysis was only possible in the younger age group in Guinea because the study was carried out too early to enrol children born after the switch in the other two countries.

PV3 seroprevalence ranged between 89% and 95%. There were no statistically significant differences between age groups or countries (Fig. 2C).

We calculated proportion of "triple negative" children – those who were seronegative for all three serotypes. There were 5/104 (5%), 6/227 (3%) and 1/195(1%) in Cote d'Ivoire, Guinea and Mali respectively among the younger age group; and none among children in the older age group.

Median reciprocal titers were higher in the younger age group than in the older age group for all three serotypes ($p < 0.05$). Median titers were highest for PV1 followed by PV2 and PV3 (Fig. 3).

We performed univariate analysis of poliovirus vaccine dose history and nutritional status to assess whether these were risk factors for seronegativity. Fifteen percent (159/1059) of children in our sample did not have antibodies against at least one poliovirus serotype. Among those with known vaccination history, there were 12% (52/432) seronegative children who had received >4 OPV doses; and 23% (91/404) seronegative children who had received <4 OPV doses (OR = 2.1 CI95% = 1.5–3.1). Among those with known nutritional status, there were 7% (30/422) seronegative normally nourished children; and 12% (22/180) seronegative acutely malnourished children (OR = 1.8 CI95% = 1.1–3.3). Chronic malnutrition was not associated with seronegativity.

4. Interpretation

We found high seroprevalence for PV1 and PV3 in both studied age groups; however, we identified important population immunity gaps in PV2 seroprevalence in the younger age group in Cote d'Ivoire and Guinea. The lower seroprevalence for PV2 in Guinea may be

explained by inclusion of children born after the switch from tOPV to bOPV. These children would have not received any type 2 live polio vaccine; instead they received one IPV dose at 14 weeks of age. Previous data on immunogenicity of one dose of IPV administered at 14 weeks of age showed seroconversion in 69–80% of children [18]. In our study we found 60% of Guinean children born after the switch who seroconverted to PV2, suggesting IPV coverage in Guinea to be in the 75–85% range.

In accordance with previous studies, we observed declining antibody titers with age [11]. Unlike in a previous study where chronic malnutrition was a risk factor for seronegativity, we identified acute malnutrition as a risk factor [19].

Our study had some limitations. We did not collect information about whether vaccination cards were available; and OPV dose history provided by parental recall may be unreliable – for example we observed that in the younger age group in Cote d'Ivoire the seroprevalence to PV1 and PV3 was similar to the other two countries despite the fact that the mean number of OPV doses in Cote d'Ivoire was 1 compared to 5 in Guinea and 3 in Mali. IPV history was not reported. Further, those children not accessed by the vaccination teams were possibly also missed by the health workers selecting children for this survey. This may have resulted in overestimation of true population immunity.

GPEI invested considerable resources to control the past poliovirus outbreaks and prevent future ones in the three African countries and their efforts seem to have paid off for PV1 and PV3. The risk of an outbreak of WPV1 following a possible importation from an endemic zone remains low. On the other hand, a growing cohort of PV2-unprotected children constitutes a risk of VDPV2 outbreak in case of an importation or in case of undetected VDPV2 circulation. As in all other countries, to minimize this risk, any detection of VDPV2 will require urgent response following established outbreak response guidelines [20].

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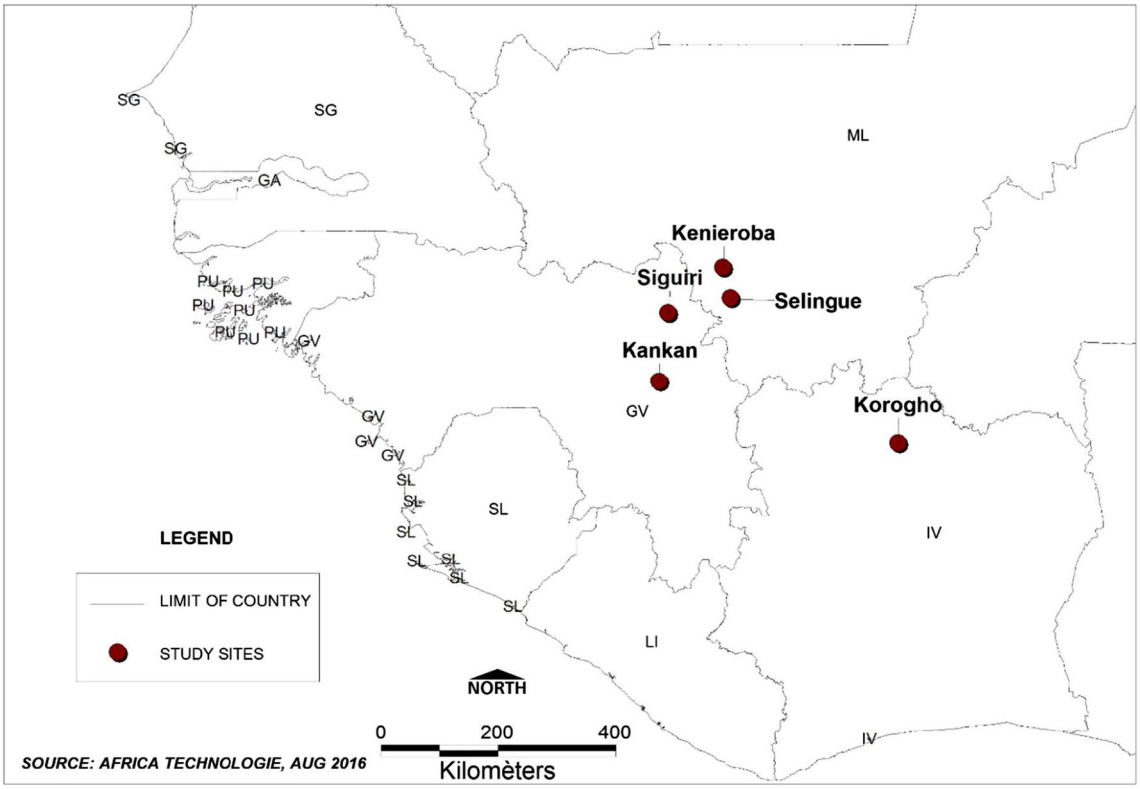

Fig. 1.
Map of the area of investigation (ML: Mali, IV: Cote d'Ivoire, GV: Guinea).

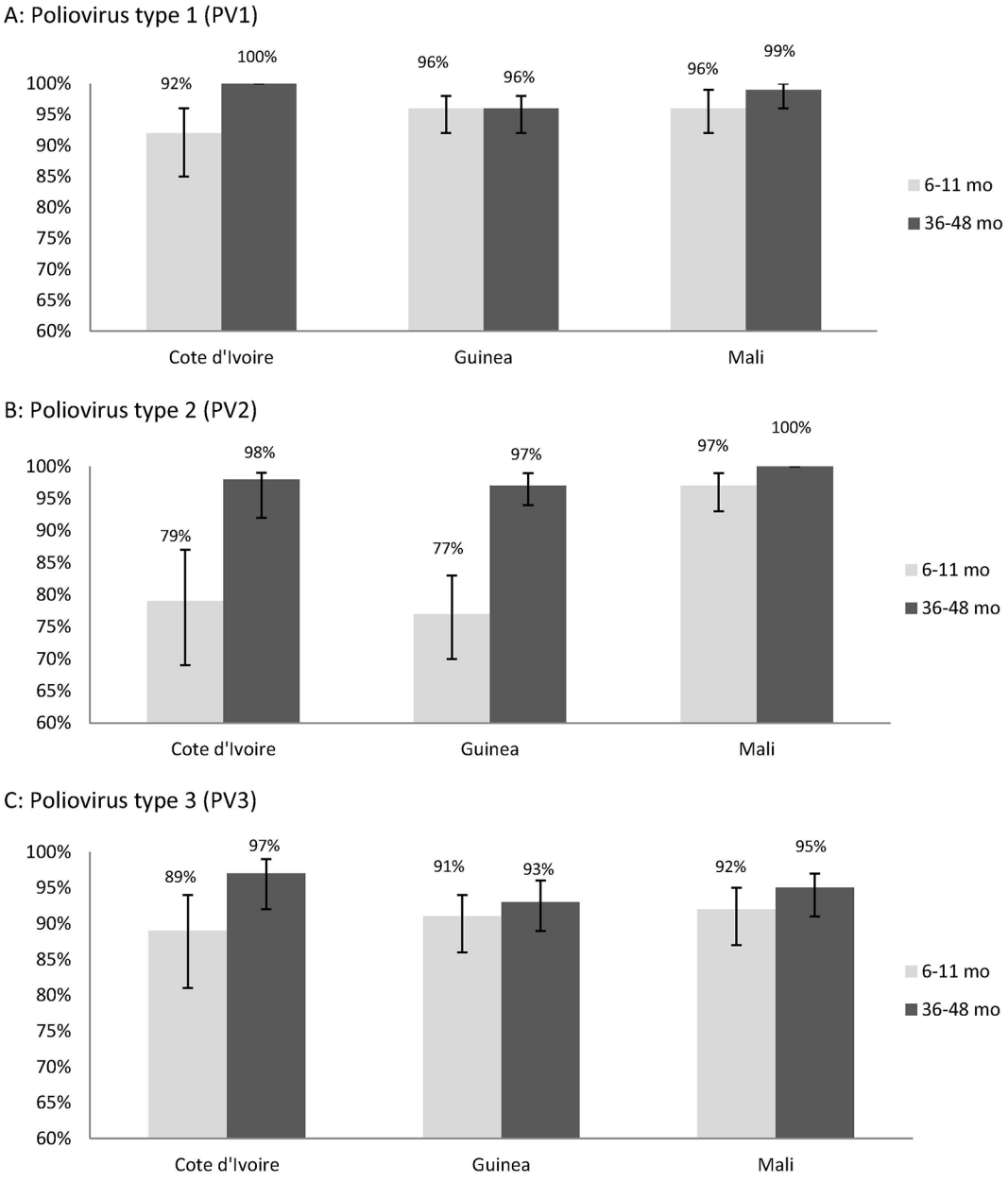

Fig. 2.
Prevalence of anti-polio antibodies [95% confidence interval shown].

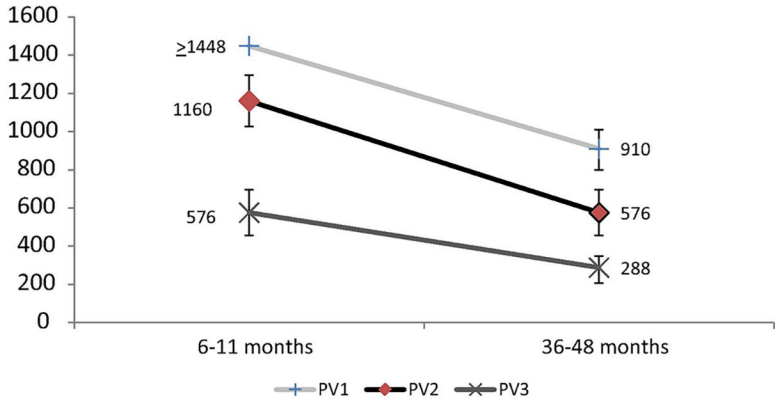

Fig. 3.

Median reciprocal titers of anti-polio antibodies (PV1–3: poliovirus type 1–3). [95% confidence interval shown].

Table 1

Demographic indicators of the study population.

	Cote d'Ivoire N = 204	Guinea N = 447	Mali N = 408	Total N = 1059
6–11 months	104	227	195	536
36–48 months	100	220	213	533
Gender female (%)	51%	51%	48%	50%
Median age (mo)				
6–11 months	9	8	9	9
36–48 months	38	36	42	39
Mean number of OPV doses received (by recall)				
6–11 months	1	5	3	3
36–48 months	7	6	7	7
DTP 3 coverage (by recall)				
6–11 months	95%	98%	77%	90%
36–48 months	99%	100%	98%	99%
Chronic malnutrition (%)				
36–48 months	19%	15%	24%	20%
Acute Malnutrition (%)				
36–48 months	13%	45%	15%	27%