

Seroprevalence of polio antibodies in adult laboratory staff in South Africa, 2009 to 2013

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The global eradication of polio has been a World Health Organization goal since May 1988 with the current target for global eradication set at 2018. A keystone of the eradication initiative is achieving and maintaining high immunisation coverage, producing high population immunity. Assessing infant vaccination coverage does not give a reliable indication of adult immunity levels as antibody titres decline with age. A requirement of the occupational health programme at the National Institute for Communicable Diseases is to test newly appointed personnel for immunity to polio. During the period 2009 to 2013, 352 sera were collected and tested by means of antibody neutralisation assays to determine immunity to all three polio serotypes. The objective of this study was to assess immunity to polio in personnel employed at the National Institute for Communicable Diseases as a proxy for the general adult South African population. The seroprevalence to polio serotypes 1, 2 and 3 were 85.5, 90.0 and 74.0%, respectively. Of the 352 samples tested, 2.3% were sero-negative for all three serotypes and 36.0% were sero-negative to at least one of the serotypes. The seroprevalence to polio serotype 3 falls below the target of 80.0%, and could pose a potential risk following importation or development of vaccine derived poliovirus type 3.

Keywords: adult, Africa, antibodies, eradication, herd, immunity, immunization, occupational, polio, poliomyelitis, sero-immunity, seroprevalence, South Africa, vaccine-derived

Background

In May 1988, the 41st World Health Assembly adopted a resolution to globally eradicate polio by the year 2000.¹ This target was not achieved, nor the two subsequent targets of 2005 and 2010. The new target for global certification of eradication has now been set for 2018.² In 1988, polio occurred in more than 125 countries on five continents and paralysis was observed in more than 350 000 children.¹ Elimination strategies that proved successful included high routine immunisation coverage; national immunisation days that targeted all children under 5 years of age; enhanced and effective acute flaccid paralysis surveillance; and, mop-up immunisation campaigns.¹ The lack of cross protection between the three polio serotypes warranted the use of trivalent vaccines during national immunisation days and campaigns, but required monovalent vaccines to eliminate wild type poliovirus 1 from India.^{3,4}

Progressing towards polio eradication, only three countries globally remain endemic for wild poliovirus type 1: Nigeria, Pakistan and Afghanistan.⁵ No wild type cases have been identified in Nigeria since July 2014.⁶ In South Africa, the last wild-type polio case was identified in 1989.⁷ Those countries that have been certified as polio free remain vulnerable to importation from endemic countries. Estimation of polio immunity in non-endemic populations can guide the vaccine policy and outbreak response guidelines. Estimation of polio vaccine coverage by the World Health Organisation (WHO) and United Nations Children's Fund (UNICEF) usually focus on children in the first year of life.⁸ The WHO-UNICEF estimate for South African children who received at least three doses of trivalent polio vaccine in 2013 was 66%, versus the official government estimate of 90%.⁸ WHO and UNICEF establish national immunisation coverage estimates by means of an annual country-by-country evaluation of all data

available, including survey-based and administrative coverage. Administrative coverage is derived from the number of vaccine doses administered to those in a specific target age group divided by the estimated target population.⁹ Survey-based coverage is vaccine coverage estimated from visiting a representative sample of households with children in a specific target age group and recording the relevant data from home-based records or verbal confirmation from caregivers.⁹ Discrepancies in administrative and WHO-UNICEF figures for South Africa derive from not having any recent coverage surveys. In 2009, South Africa introduced an inactivated polio vaccine (IPV) into its routine immunisation schedule, with an oral polio vaccine (OPV) given at birth and six weeks and IPV given at six, ten and fourteen weeks, as well as at eighteen months.^{10,11}

The keystone of the global polio eradication initiative (GPEI) is to achieve and maintain high (>80%) immunisation coverage in children in their first year of life with a minimum of three polio vaccine doses given as part of the routine immunisation schedule.¹² South Africa has increased this target to 90%.¹³ Polio immunity wanes with time and the immune status of adults is not often assessed. For outbreak preparedness in the case of importation of wild or vaccine-derived poliovirus (VDPV) at this stage of the polio eradication endgame, it is critical to have estimates of adult as well as paediatric immunity.

Methods

Subjects

The National Institute for Communicable Diseases (NICD) routinely tests newly appointed staff members for immunity as part of their occupational health programme. During the period 2009 to 2013, a total of 352 adult staff members of NICD,

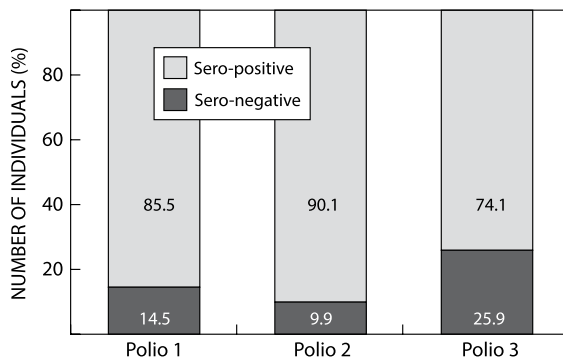


Figure 1: Seroprevalence of polio antibodies in employees of the National Institute for Communicable Diseases, 2009 – 2013.

Johannesburg, South Africa were tested for pre-existing immunity to polio. Data was extracted from an access database maintained at NICD. Individuals were all adults greater than 18 years of age. Geographic information, namely home province or district, gender and race were not captured at the time of sample collection and testing. Protective immunity against all three polio serotypes was tested by the microneutralisation test for polio antibodies, the gold standard assay. Where results provided evidence of non-protective immunity to one or more serotypes, individuals were offered immunisation and retested after a period of time to confirm seroconversion. The results of follow up testing have not been included in this analysis.

Polio antibody assay

Sera from individuals were diluted 1:8 and heat inactivated at 56°C for a period of 30 minutes. Ninety-six well microtiter plates were prepared for serum dilutions from 1:8 to 1:512. Aliquots (0.05 ml) of the heat-inactivated sera were subsequently added to microtiter plates and serially diluted. Equal volumes of 100CCID₅₀/0.05 ml virus preparations were added. Virus preparations were diluted from authenticated Sabin reference strains obtained from the National Institute for Biological Standards and Controls (NIBSC, UK). Reference numbers of the authenticated strains from NIBSC for polio types 1, 2 and 3 are 01/528, 01/530 and 01/532, respectively. This mixture was incubated at 37 °C for 3 hours to allow for any specific antigen-antibody reaction to take place. Following incubation, 0.1 ml of a cell suspension prepared from RD (rhabdomyo sarcoma) cells at 0.5 × 10⁵ cells/ml were added to all wells of the test plates and plates were further incubated in a 37 °C incubator with 5% CO₂. The antibody titre was determined from examining plates under an inverted microscope for the inhibition of typical viral

cytopathic effect, which would indicate the presence of neutralising antibodies in the sera. The endpoint titre was taken as the highest dilution of serum that inhibited viral cytopathic effect. A titre of ≥1:8 is considered positive for immunity and, thus, protective.¹⁴ The polio antibody microneutralisation assay is routinely used at the NICD and is accredited by the South African National Accreditation System (SANAS). The NICD is a World Health Organization regional reference laboratory for polio testing.

Results

From the total of 352 samples tested over a five year period, the seroprevalence to polio antibody types 1, 2 and 3 were 85.5% (301), 90.1% (317) and 74.1% (261) respectively (Figure 1).

These results are in line with results obtained from a previous study conducted in South Africa and other studies conducted in Portugal, Brazil, and Israel.^{15–18} Using consolidated data for the five years, 36.4% (128 of 352) of the personnel tested had a titre of less than 1:8 for at least one polio serotype and 2.3% (8 of 352) had a titre of less than 1:8 for all three serotypes (Table 1).

Discussion

With global eradication of wild poliovirus type 2 in 1999 and global interruption of wild poliovirus type 3 circulation in 2012, it is wild poliovirus type 1 and vaccine derived polioviruses that remain a risk.^{19,20} Circulating vaccine derived polioviruses (cVDPVs), particularly derived from poliovirus serotypes 2 and 3, remain a threat to the eradication initiative. Therefore, it is crucial to identify populations that are vulnerable to any of the serotypes.

For outbreak preparedness, it is advisable to have estimates of population immunity. While childhood vaccine coverage is estimated by WHO-UNICEF, adult immunity requires laboratory testing. Polio immunity tests are challenging as they require live virus neutralisation, a technique that is time consuming and labour intensive. Such tests are, therefore, not often conducted on the low risk, healthy adult population. Staff working at NICD must show evidence of protective immunity to all three polio serotypes prior to handling potentially infectious materials, and screening for protective immunity is therefore compulsory. Staff immunity rates may act as a proxy of rates in the general adult population.

Our retrospective review of adult staff immunity rates to polio from the years 2009 to 2013 showed that 85.5% had titres greater than or equal to 1:8 for serotype 1, 90.1% for serotype 2 and

Table 1: Personnel of the National Institute for Communicable Diseases tested for polio neutralising antibodies 2009 – 2013

Year	Total Tested	Number with antibodies to all 3 serotypes	A titre of less than 1:8 as observed on initial testing per serotype alone or in combination with other serotypes								Total with at least one serotype with a titre of less than 1:8	
			P1	P2	P3	P1,P2	P1,P3	P2,P3	P1,P2,P3	Number	Percentage of total tested	
2009	95	67	4	2	15	1	2	2	2	28	29.5	
2010	51	31	3	2	8	0	5	2	0	20	39.2	
2011	116	85	2	2	14	2	6	3	2	31	26.7	
2012	41	23	7	0	9	0	0	1	1	18	44	
2013	49	18	4	4	11	4	3	2	3	31	63	
Total	352	224	20	10	57	7	16	10	8	128	36.4	

Notes: P1 = Polio serotype 1; P2 = Polio serotype 2; P3 = Polio serotype 3.

Table 2: Polio seroprevalence in various geographic areas

Country	Year	Age Group	Number of participants	Seroprevalence in percentage			Reference
				P1	P2	P3	
South Africa	1979-1999	> 18 years	776	92	94	87	18
South Africa	1995	12-35 months	1290	99.5	99.1	99.8	22
Zaria, Northern Nigeria	2008-2009	1-10 years	264	86.4	76.1	77.3	23
Riverine areas of Delta State, Nigeria	Unknown	≤10 years	200	89	90	90.5	24
Kano, Northern Nigeria	2011	6-9 months, 36-47 months	313	86	81	79.5	25
Milan, Italy	1991	18 years	530	92	99	96	14
Italy, nationwide	1978-1982	6 months to 79 years	3834	96.1	98	95.2	26
Korea	1999	Primary school children	500	94.4	96.4	86.8	27
Border provinces in China	2010	<15 years of age	1360	89.7	92.6	81.8	28
Sao Paulo, Brazil	1996-1997	2-≥60 years	1059	94.6	98.8	91.9	16
Portugal	2002	2-≥60 years	1133	95.2	97.1	88.9	15
Netherlands	1995-1996	All age groups	7773	96.6	93.4	89.7	13
Dominican community, Puerto Rico	2002	7-60 months,	180	94.4	97.8	93.3	29

74.1% for serotype 3 with 36.4% of the total of 352 having a titre of less than 1:8 for at least one of the three serotypes.

A previous study in South Africa that assessed seroprevalence to polio from 1979 to 1999 in the same population group as our study reported seroprevalences of 92, 94 and 87% to polio serotypes 1, 2 and 3, respectively.¹⁸ Compared with this group, a decline in seroprevalence to all three polio serotypes is seen. Such declines are concerning but may reflect the absence of wild type poliovirus in the country since 1989.⁷ The seroprevalence remains highest to serotype 2 and lowest to serotype 3.

WHO and UNICEF estimates on national immunisation coverage are available for most countries from 1980.²¹ For South Africa, the coverage data is available from 1983 up to and including 2013 and is given in supplementary Table 1.⁸ A minimum of 65% coverage was seen in 2004 and maximum of 82% in 1991 with a median coverage of 73%. The coverage for 2013 is estimated at 66%, just 1% higher than the lowest of 65% in 31 years. Such figures may suggest that lower immunity rates should be expected in future studies of adult immunity.

Several studies on polio immunity conducted elsewhere have shown a similar picture in adults in that seroprevalence to polio serotype type 2 is usually highest and type 3 lowest.¹⁵⁻¹⁸ In contradictory studies, the seroprevalence was highest to polio serotype 1 in adults in the Netherlands and lowest for serotype 1 in 18-year-old men residing in Milan, Italy.^{13,14} Table 2 highlights results obtained from several studies on polio immunity in all age groups. Due to the nature of the study, there are several limitations, including the lack of geographic and demographic information, absence of vaccination history, and unknown HIV status. The advantage of this type of a study is that the data reflect a real world snapshot of a mixed-age population, specifically healthy adults who work in Gauteng but drawn from multiple geographic areas of the country to the Gauteng commercial hub. Ours is a convenience sample that can be periodically repeated as results of routine staff immunity tests are archived at NICD. Such results may be regarded as a proxy for adult immunity screening.

Conclusion

The relatively high serotype specific immunity levels (above 80% for serotypes 1 and 2) in the adult population provide evidence of long-lived immunity, most likely induced through childhood vaccination with OPV. The seroprevalence for poliovirus type 3 was lower and could pose a potential setback following any emergence or importation of serotype 3 VDPV in the future. Taken together, 36.4% (128 of 352) of personnel tested had non-protective antibody titres for at least one polio serotype. Such information can be used to support outbreak preparedness planning. Should importation of wild-type poliovirus or VDPV occur, South Africa would require supplementary immunisation activities, including for adult populations.

Supplementary material

Supplementary material for this article can be accessed here <http://dx.doi.org/10.1080/23120053.2016.1128149>.

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