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DETECTION OF IMMUNOGLOBULIN G TO POLIOVIRUS IN CHILDREN 5-10 YEARS OLD IN MINNA, NIGERIA

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Abstract

In the Minna, data on the seroprevalence rate of antibodies to poliovirus serotypes which can be used to determine children's immune status and the vaccine efficacy against poliomyelitis is sparse. This study aim was to detect immunoglobulin G to poliovirus in children aged 5-10 years old in Minna, Nigeria. About 2 mL of blood was collected by venipuncture from 91 children selected randomly from various health care facilities across Minna. Blood samples were centrifuged to obtain the sera. The detection of poliovirus specific immunoglobulin G (IgG) was done using polyclonal Enzyme linked immunosorbent assay (ELISA) detection test kits. In this study, all the children had detectable level of antibodies, 85 (93.4%) children consisting of 49 (53.8%) males and 36 (39.6%) females showed protective level of antibodies (seropositive). Seropositivity rate of 96.8% (30/31), 94.0% (31/33) and 88.9% (24/27) was recorded among children aged 9-10, 7-8 and 5-6 years old

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respectively. About 74.7% (68/91) of the participants were weak responder (concentration of antibodies <50 U/mL) to the vaccines received with low seroconversion rates while 6.6% (6/91) of the children had sub-protective level of antibodies (seronegative). Age, sex, parents' occupation, mothers' educational status and drinking water source had no significant association ($p>0.05$) with seroprevalence rates while fathers' educational status showed significant statistical association with seroprevalence rate ($p<0.05$). High seropositivity was recorded in this study, nation-wide seroprevalence is recommended to comprehensively evaluate the progress made so far in sustaining polio-free status.

Keywords: Antibodies, Immunoglobulin G, Poliomyelitis, Seroconversion rate, Seropositivity

INTRODUCTION

Nigeria has interrupted transmission of wild poliovirus, making African region polio-free and bringing the World closer than ever to being polio free (Centre for Disease Control and Prevention (CDC), 2020; Scherbel-Ball, 2020). Poliomyelitis is on the verge of been eradicated globally, the cases that do occur are caused mainly by wild poliovirus 1 or vaccine-derived poliovirus, within groups that are under-immunized (Mehndiratta *et al.*, 2014). As of May 5, 2021, more than 200 cases of WPVs and about 900 cases of circulating vaccine-derived polioviruses (cVDPVs) have been reported globally (Global Polio Eradication Initiative (GPEI), 2021). Circulating vaccine-derived polioviruses are caused by excreted vaccine viruses which circulate and can cause paralytic cases in populations with poor immunity (Ming *et al.*, 2020).

Critical activities necessary to interrupt transmission and maintain a polio-free world becomes more crucial as the world draws closer than ever to eradicating the notorious wild poliovirus (WPV) (Konopka-Anastadt *et al.*, 2020). Poliomyelitis (polio) caused by poliovirus is a disease that has caused permanent disability and even death to thousands of children, especially those between the age of 0-15 years (Bulama and Goodman-Brown, 2019). Polioviral infection results in clinical manifestations which ranges from in-apparent infection, nonspecific febrile illness, aseptic meningitis to paralysis and even death (John *et*

al., 2013). Poliomyelitis is one of the most thoroughly studied diseases, though it has no cure but can be prevented through vaccination (Wood and Thorley, 2003; Baicus, 2012).

Nigeria has been certified as polio-free for the first time, preventing the introduction of wild polioviruses into the country and sustaining measures to curb the spread of circulating vaccine-derived polioviruses becomes paramount (The United Nations Children's Fund (UNICEF), 2020; The Lancet Global Health, 2020). In the study area, polio vaccines have been administered to children during routine immunization and campaign sessions but their effectiveness with respect to the children's immune status was not ascertained duly. Any country that has implemented a systematic program to vaccinate children against poliovirus, is required to conduct serological studies on the immune status of the eligible children, or even the whole population, on a regular basis (Bulama and Goodman-Brown, 2019). Countries can risk losing their polio-free status if they are not careful, as was seen in the case of South Africa, Congo and China (Yu *et al*., 2014; Alleman *et al*., 2014; Roberts, 2018). In the study area, data on the seroprevalence rate of antibodies to poliovirus serotypes, which can be used to determine children's immune status and the vaccine's efficacy against poliomyelitis (Giwa *et al*., 2012), is sparse Children above the age of 5 years are exempted from routine immunization and supplemental immunization activities (Shehu and Awa-Agwu, 2019) and also, most of the studies (Dashe *et al*., 2010; Donbraye *et al*., 2011) conducted in the country placed emphasis on children below the age of five, even though children above the age of five years can be susceptible to poliomyelitis (Blake *et al*., 2014). Seroprevalence is a useful tool for assessing the performance of immunization activities, evaluating the populations immunity to poliovirus and discovering areas with low immunity (Li *et al*., 2021). Low seroprevalence of poliovirus antibody in a population could result in polio outbreak (Opare *et al*., 2019). The data generated from this study may serve as an immunity benchmark for the study area against any polio infection to enable identification of the populations at risk of future polio outbreaks and also to determine the effectiveness of the vaccination and generate the prevalence data for monitoring, re-planning, implementation and evaluation to ensure total eradication with no possible recurrence. The objectives of the study were to determine the seroprevalence of poliovirus immunoglobulin G in children aged 5-10 years old and the socio-demographic factors associated with poliovirus immunoglobulin G seropositivity and seronegativity in children in Minna, Nigeria.

METHODS

Study Area

The study was carried out in Minna, the capital of Niger State in Nigeria. It is located 9.62 latitude and 6.55 longitudes and it is situated at elevation 243 meters above sea level. Minna is the biggest city in Niger State, it has an estimated population of 462,743 of which majority are in the age group 0-10 years old (World Population Review, 2021). The inhabitants of Minna are predominantly Nupe, Gbagyi, Hausa and Fulani with a mixture of other ethnic groups in Nigeria. Local indigenes are mainly farmers, traders, artisans and civil servants.

Study Design

This was a four months cross sectional descriptive and health facilities-based study. Major health facilities in Minna Metropolis such as; General Hospital Minna, Ibrahim Babangida Specialist Hospital Minna, Bosso Primary Health centre, Asibitin Mata Town Primary Health centre, Primary Health care Tunga, Standard Hospital Minna and Old Airport Road Primary Health Centre were selected for the study. Children were selected randomly from each health facility until the number of study sample size was obtained. Parents/guardians with eligible child/children attending designated health facility for services were contacted for possible participation. Informed consent forms were issued out to the parents/guardians. Social demographic data, vaccination history and other relevant information of each participant was obtained using a structured questionnaire.

Study population

The study population consists of vaccinated children aged 5-10 years old residing in Minna, whose parent/guardian consented to the collection of their blood sample.

Sample Size

The sample size was calculated using the formular (Ngowi *et al.*, 2007) below. The prevalence of 94.1% obtained in polio antibody prevalence survey conducted in Kano, Nigeria (Aminu *et al.*, 2007) was used.

$$n = \frac{Z^2pq}{d^2}$$

Where; n = sample size, Z = confidence interval (1.96), p = prevalence rate from previous study (0.941), q= 1-p which is 0.059, L= the allowable error (5%) = 0.05

However, a total of 91 samples were examined.

Sample collection and processing

About 2 mL of blood sample was collected aseptically by venipuncture from each child. Blood samples were collected into sterile plain blood collection tubes free of anticoagulants and labelled. The samples were centrifuged at 3000rpm for 5 minutes in order to separate the sera. Serum of each sample was aspirated using a sterile Pasteur pipette and transferred aseptically into labelled sterile tubes and stored at -20˚C until required for use.

Detection of antibodies to polio virus

The detection of immunoglobulin G (IgG) specific for Poliovirus from the processed blood samples was carried out using polyclonal Enzyme linked immunosorbent assay (ELISA) detection test kits (Demeditec Diagnostics GmbH, Germany) following the manufacturer's instructions. The calculated absorption (optical density (OD) value) for the sera were compared with the value for the cut-off standards. Positive result was recorded for the samples with OD value higher than the cut-off standard while for the values below the cut-off standard, negative result was recorded. The absorption of the standard and controls were graphically drawn point-to-point toward their concentrations using automated computer programs for a quantitative assessment. The concentration values for each patient population were then extracted in comparison to their absorption from the resultant reference curve using the equation of the graph.

Data Analysis

Data generated from the study was analysed using SPSS version 25 Software. Results was presented as percentages, while chi-square and student T-test was used in determining any significant association with regards to socio-demographic and other associated risk factors among the studied children. A p-value of 0.05 or less was considered significant at 95% confidence interval.

RESULTS

Table 1 showed the distribution of immunoglobulin G to poliovirus based on gender and age of the participants. Out of 91 serum samples analysed, 85 (93.4%) children consisting of 49 (96.1%) males and 36 (90.0%) females showed protective level of IgG. The highest seropositive rate was recorded among age group 9-10 years (30/31, 96.8%) followed by 7-8

years (31/33, 94.0%) and the least was recorded in age group 5-6 (24/27, 88.9%). Age ($\chi 2 = 1.450$; df = 2; p = 0.505) and gender ($\chi 2 = 1.345$ df =1, p = 0.399) was not statistically significant.

Table 1: Distribution of Immunoglobulin G to Poliovirus among Children 5-10 years in Relation to Gender and Age

	Number examined	Number positive	Percentage positive (%)	p-value
Sex				
Male	51	49	96.1	
Female	40	36	90.0	0.399
Total	**91**	**85**	**93.4**	
Age group (years)				
5-6	27	24	88.9	
7-8	33	31	94.0	0.505
9-10	31	30	96.8	
Total	**91**	**85**		

The result for concentration <10 U/mL was 6 (6.6%) while 10-49 U/mL was 62 (68.1%), 50-89 U/mL was 17(18.7%) and concentration >90 U/mL was 6 (6.6%). There was no significant statistical association ($\chi 2 = 3.372$; df = 6; p = 0.789) between concentration of antibodies and age group of children as presented in Table 2.

Table 2: Distribution of Concentration of Poliovirus Immunoglobulin G in Relation to Age Group

Concentration (U/mL)	Age groups (years)			
	5-6 Frequency (%)	7-8 Frequency (%)	9-10 Frequency (%)	Total Frequency (%)
<10	3 (11.1)	2 (6.1)	1 (3.2)	6 (6.6)
10-49	16 (59.3)	24 (72.7)	22 (71.0)	62 (68.1)
50-89	5 (18.5)	6 (18.2)	6 (19.4)	17 (18.7)
>90	3 (11.1)	1 (3.0)	2 (6.5)	6 (6.6)
Total	**27**	**33**	**31**	**91**

($\chi 2 = 3.372$; df = 6; p = 0.789); Concentration <10 U/mL implies seronegative

Highest seropositive rate (97.5%) was recorded among children whose father had tertiary education while the least was recorded among children whose father had no formal education. There was a significant statistical association (χ^2 = 9.679; df = 3; p=0.012) between the level of education of the subjects' father and seropositivity rate. High seropositivity rate of 100.0%, was observed among children whose mothers had secondary level of education while the least seropositivity rate (88.6%) was observed among children whose mothers had no formal education. There was no significant statistical relationship between seropositivity rate and the mothers' level of education ($\chi 2$ = 2.101; df =3; p = 0.608). Children whose fathers were traders had the highest seropositivity rate (95.8%). though there was no statistical relationship ($\chi 2$ = 1.780 df =3; p = 0.709) between the fathers' occupation and seropositivity rate. Seropositivity rate of 100.0%, 95.0%, 91.3% and 91.3% was observed among children whose mothers were traders, farmers, civil servants and housewives respectively, also there was no statistical relationship between the mothers' occupation and seropositivity rate ($\chi 2$ = 2.673; df =3; p = 0.525) as shown in Table 3.

Table 3: Distribution of Poliovirus Immunoglobulin G in Children 5-10 years in Relation to Parent's Occupation and Level of Education

	Father Number positive (%)	Mother Number positive (%)
Occupation		
Civil servant	32 (94.1)	21 (91.3)
Artisan/Housewife	18 (94.7)	21 (91.3)
Trader	23 (95.8)	24 (100.0)
Farmer	12 (85.7)	19 (95.0)
p-value	0.709	0.525
Level of Education		
None	22 (91.7)	31 (88.6)
Primary	8 (80.0)	14 (93.3)
Secondary	16 (94.1)	15 (100)
Tertiary	39 (97.5)	25 (96.2)
p-value	0.012	0.608

There was no significant statistical relationship between source of drinking water and seropositivity rate ($\chi 2$ = 5.507; df = 3; p = 0.091). Highest seroprevalence rate of 100.0%

was observed among children whose source of drinking water was bore hole The least seropositivity rate of 75.0% was observed among children whose source of drinking water was other source (apart from borehole, well and tap) Seropositivity rate of 97.2%, 93.0% and 83.3% was observed among children who used water cistern, pit latrine and open dumping as their toilet facility. There was no significant association between seropositivity rate and type of toilet facility ($\chi 2 = 2.828$; df =2; p=0.181) as presented in Table 4.

Table 4: Distribution of Poliovirus Immunoglobulin G among Children aged 5-10 years in Relation to Source of Drinking Water and Type of Toilet Facility

	Number positive (%)	p-value
Source of drinking water		
Bore hole	27 (100.0)	
Tap	33 (94.3)	
Well	22 (88.0)	0.091
Others	3 (75.0)	
Total	85	
Type of Toilet Facility		
Water cistern	35 (97.2)	
Pit latrine	40 (93.0)	0.181
Open dumping	10 (83.3)	
Total	85	

DISCUSSION

Sustainability of high population immunity to poliovirus transmission is crucial for polio eradication, but poliovirus immunity remains poorly understood despite decades of research (Duintjer-Tebbens *et al.*, 2013). In this study, 85 children (93.4%) were found to have IgG antibodies against poliovirus. This high seropositivity indicate high efficacy of the polio vaccine administered in the study area. This finding is similar with the earlier finding in Kano by Aminu *et al.* (2017), who reported 94.1% seropositivity among children aged 1-10 years. However, the percentage is lower than the rate obtained in the findings of Dashe *et al.* (2011) and Aliya *et al.* (2015), which recorded seropositivity rate of 97.8% and 98.8% respectively.

It is noteworthy to say that the seropositivity rate obtained in this study is higher than that of similar study (70.0%) in a study earlier conducted in Bida, Niger State (Oladejo *et al.,* 2013). The variation in this report and earlier study may be due to differences in geographical location and the study population.

The result showed that 6.6% of the subjects were seronegative in spite of history of complete routine immunization. This implied that these children were unprotected against poliovirus and they could serve as a potential source of re-introducing poliovirus into study area in case of cross-country transfer of infection. The study suggested that the vaccines received by the subjects may have lost its immunogenicity, failed to seroconvert or wrong immunization history was provided by the parents/guardians. Seronegativity rate recorded in this study agrees with the previous report of 5.9% and 7.9% by Aminu *et al.* (2017) and Adeniji *et al.* (2015) respectively.

Gender has no significance (P>0.05) on the seroprevalence of poliovirus antibodies, even though the percentage of seropositive male 96.1% (49/51) was higher than that of the female 90.0% (36/40). This could be as a result of both gender equal chance of vaccination and seroconversion. Oladejo *et al.* (2013) also recorded a higher prevalence of antibody in male while Yusuf *et al.* (2015) observed that females have higher seropositivity rate. The findings of this study also confirmed an earlier observation by Aminu *et al.* (2017) which recorded no significant association between gender and seropositivity rate. However, this was in contrast with other studies (Yusuf *et al.*, 2015, Donbraye *et al.*, 2011) which recorded significant statistical association between gender and seropositivity rate.

About 88.9% (24/27), 94.0% (31/33) and 96.8% (30/31) seropositive rate was recorded for the age group 5-6, 7-8 and 9-10 respectively. The seropositive rate seems to increase with age though there was no statistical association (P>0.05) between seropositivity rate and age group. This agrees with the findings of Adewumi *et al.* (2006) and Dashe *et al.* (2011) that stated seropositive prevalence rate increases with age in children.

Majority of the participants (74.7%) in the study had low seroconversion rates. Low seroconversion rate suggested the existence of children that are susceptible to poliovirus virus infection in the population and might be due to a number of reasons such as incomplete vaccination, simultaneous enteroviral infection, interloping between serotype of oral polio vaccines and unavailability of good water supply as well as inadequate sewage treatment (Tao *et al.*, 2013; Alattas, 2017). Poor maintenance in cold chain and sub optimal

processing of vaccines could affect the quality of the vaccine and ultimately result in low seropostivity (Centre for Disease Control and Prevention, 2021). Previous studies by Magrath *et al.* (1981) and Nishio *et al.* (1984) have shown that children with low concentration of antibodies could be re-infected with wild or vaccine derived virus. Children in this category may not be in danger of developing poliomyelitis but may be re-infected with poliovirus and possibly provide a source of infection for other children who have not been vaccinated (Thompson *et al.*, 2013, Adeniji *et al.*, 2015).

Immunization coverage as well as the level of awareness on the need to get children immunized against the poliovirus has increased tremendously among the populace. This study reiterates the facts that the more educated a parent is, the more the seropositive rate, though children whose parents were uneducated also had high seropositivity rate of antibodies to the poliovirus. There was significant association ($P<0.05$) between seropositivity rate and fathers' educational level.

Furthermore, poor sanitation has always been a major drivers of poliovirus infection (Richard *et al.,* 2014). Unavailability of portable water and inadequate sewage treatment have also been attributed with lack of seropositivity or low seropositivity (Tao *et al.*, 2013). However, toilet facilities and drinking water source were found not to influence the seropositivity of the participant in this study.

All the subjects had detectable antibodies to poliovirus even though some were not up to protective level. This might be explained by a number of reasons such as failure of vaccines, acquisition of antibodies due to natural infection or exposure to excreted vaccines (Yusuf *et al.*, 2015). In Nigeria vaccine failure is likely, due to sub-optimal storage of vaccine, inadequate cold chain maintenance during transport and storage or incorrect vaccination protocol. Host factors such as the failure of the subjects to develop an immune response to vaccination due to a number of conditions; immunosuppressive therapies and recognised immunodeficiency illness or blood transfusion may have impaired immune response.

Likewise, persistent of passively acquired maternal antibody may have attenuated immune response. Post vaccination immune response against poliovirus may wane over time, especially if boosting from exposure to natural infection does not occur, so the longer the duration since vaccination the more likely is secondary vaccine failure to occur. There are evidences that children immunized with polio vaccine are as likely to get infected with live

virus as the unvaccinated children. Polio vaccination then can only protect the vaccinated person. Therefore, even if polio vaccination were 100% effective, every person would have to be immunized in order to eradicate the disease completely.

CONCLUSION

This study recorded high seropositivity rate of poliovirus immunoglobulin G among vaccinated children aged 5-10 years residing in Minna, Nigeria. Though, high serologic performance is achieved, immunity gaps in young children remains as majority of the population had low concentration of poliovirus immunoglobulin G. This immunity gaps might pose risk for polio re-infection and emergence of vaccine-derived polioviruses. Socio-demographic factors such as age, gender, mother's education, parents' occupation, source of drinking water and type of toilet facilities have no influence on the distribution of seropositivity and seronegativity rate in children. It is critical to avoid the risk of reintroduction of wild poliovirus into the country. Improving measures and interventions aimed at monitoring and enhancing coverage against poliomyelitis in children would help achieve this target.

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