

*Full Length Research Paper*

# Immunological evaluation of sequential poliovirus vaccination among Saudi and non-Saudi children living in Jeddah

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**Poliomyelitis is a life-threatening acute paralytic disease caused by Poliovirus (PV). In the present study, the immunostatus of polio-vaccinated children and young adults (1 to 21 years old) living in Jeddah, Saudi Arabia was investigated to ascertain their extent of protection against the virus. Children were categorized in three groups: (A) Immunocompetent: Group I: Vaccinated by IPV at first and, Group II- Vaccinated by OPV at first; (B) Immunocompromised: Tuberculosis (T.B), diabetes, AIDS, congenital immunodeficiency; and (C) Control group: healthy children vaccinated at a private hospital in Jeddah-IMC hospital. Blood samples (692) were collected from the children admitted to Hospital children wards of King Abdulaziz University Hospital-KAUH (Government), and International Medical Center Hospital-IMC (Private) in Jeddah City, for routine medical examination checkup, during a 24-month period, from January 2015 to December 2016. A total of 228 (32.95%) were Saudis and 464 (67.05%) were non-Saudi individuals. The number of samples found to be negative for polio immunoglobulin G (IgG) and were considered as non-immune children was 72 (10.4%) while the overall immune responders were 584 (84.4%). 36 (5.2%) were low positive and their immunity against polio infection was doubtful. Non-Saudi seronegative subjects varied from 28 (6.03%) Yemani, 24 (5.17%) Somalian, 8 (1.72%) Afghani, 4 (0.86%) Indians, 3 (0.65%) Chadian, 2 (0.43%) Pakistanis; to 2 (0.43%) Nigerians. Based on the present data, we recommend higher vaccination coverage and sensitive surveillance investigation in polio-free countries. Evaluation of vaccination programmes should be carried out for the early detection of immune negative and disease-susceptible individuals.**

**Key words:** Poliomyelitis, poliovirus vaccination, seronegative, immunization, immune response.

## INTRODUCTION

Poliomyelitis is a life-threatening acute paralytic disease caused by poliovirus (PV). Coxsackie A7, however, causes a non-Poliovirus flaccid paralysis (Bodian et al., 1949; Bodian, 1972; Nathanson and Martin, 1979; Brack, 1987; Moriniere et al., 1993; Hovi et al., 2005; Thompson

et al., 2006; Vancelik et al., 2007; Patel and Orenstein, 2016).

It is one of the major four contagious diseases in the world, with low mortality, but high morbidity rates (Bodian et al., 1949; Thompson et al., 2006; Dhole et al., 2009;

Mugisha et al., 2010). Poliovirus belongs to the Enterovirus genera, Picornaviridae family with three distinctive serotypes (Type 1, 2, and 3) (Bodian et al., 1949; Thompson et al., 2006; Dhole et al., 2009; Mugisha et al., 2010). Poliovirus can be transmitted primarily through the fecal-oral route and also the respiratory system.

In the 1970s, the World Health Organization (WHO) recommended and introduced an expanded immunization programme in which a Poliovirus vaccine dose was given to each child. Still, this never reached a complete coverage with adequate high levels; hence at the beginning of the millennium, the Wild Polio Virus was re-emerged in considerable number of supposed polio-free countries, which confirms the ultimate fragile herd immunity in those countries (Hovi et al., 2011).

In humans, the virus replicates at the intestinal tract and it is released with the stool usually for 2 to 4 weeks after infection. The virus spread is related to poor hygiene, and sewage-treatment services. Faeces serve as a contamination source of water, milk, and food. Hence, young children are probably the most important transmitters of Enteroviruses.

The accreditation of inactivated poliovirus vaccine (IPV) in 1955 and Oral Polio Vaccine (OPV) in 1962 encouraged the worldwide beginning of vaccination programmes (Nathanson and Martin, 1979; Cheuk, 2007). The IPV is prepared by inoculating the monkey kidney tissue culture (vero cell line) with the poliovirus (CDC, 2001a, b).

The vaccine contains the three poliovirus serotypes (CDC, 2001a, b), which induces effective circulation of antibodies in blood, thereby preventing any polio virus that finds its way to the intestine from entering and replicating in the central nervous system (Vancelik et al., 2007).

On the other hand, the live-attenuated vaccine is a trivalent vaccine, containing the three serotypes of poliovirus in a ratio of 10:1:6 (CDC, 2001a, b; Kew et al., 2004). These weakened PV strains replicate in the human intestine and induce mucosal immunity that prevents the viral replication at the gastrointestinal tract (CDC, 2001a, b; Kew et al., 2004; Cheuk, 2007). The OPV yields lifelong mucosal immunity by encouraging production of IgA antibody in the intestinal tract and furthermore serum antibodies in the circulating blood (Pelczar et al., 1993; Cheuk, 2007).

Polio national immunization schedule in Saudi Arabia includes a vaccination with IPV at 2 months of age, followed by OPV in 4,6,12,18 months, and an OPV booster dose at the primary school entry (MOH). In the meantime, starting from April 2016, all nations using OPV have converted to bivalent OPV (bOPV) as part of the

last steps for universal elimination of all-cause poliomyelitis. bOPV retains safety against type 1 and 3 polioviruses, but leaves young children susceptible to infection by type 2 vaccine-derived polioviruses (Bandyopadhyay et al., 2015; Patel and Orenstein, 2016).

To support the population immunity and confirm that all children are safe against type 2 polioviruses in nations that are polio-endemic, or at great danger of the virus importation, the WHO Strategic Advisory Group of Experts (SAGE) recommends at least one dose of IPV, given with the third dose of bOPV at 14 weeks of age or older, to decrease the interloping from maternally-derived antibodies (WHO, 2013).

In nations with 90 to 95% immunization report of low importation threat, IPV-OPV sequential schedules can be used to reduce the risk of vaccine-associated paralytic polio (VAPP) (Lopez-Medina et al., 2017; WHO, 2004).

Moreover, studies that approved a sequential schedule of immunization from other nations that administered multiple IPV doses followed by various OPV doses received by infants, have furthermore established that VAPP was eradicated. Nevertheless, the risk of VAPP was not explicitly estimated in nations that embraced the recently recommended universal polio immunization schedule which is: 3 doses of OPV plus a singular dose of IPV at 14 weeks of age (Progress toward Interruption of Wild Poliovirus Transmission-Worldwide, 2006).

A major difference exists between private and government hospitals (MOH) in Jeddah, Saudi Arabia, in terms of quality and standards. Aside the low standard of some Health centres or hospitals, there are many other factors that also influence the efficacy of the administered vaccines such as: storage, transportation, and availability of qualified health providers. Since most pilgrims with unidentified vaccination status constitute a group at high risk in the situation of wild polioviruses importation into the Saudi Arabian Kingdom, it is thus essential to continue seroepidemiological monitoring.

And to effectively evaluate the influence of vaccination schedules on the people's immune status as well as to improve immunization programmes, virological and immunological studies are, no doubt, required (Patriarca et al., 1991; Moriniere et al., 1993; Pelczar et al., 1993; Fine and Carneiro, 1990; The Annual Statistics Book of Health, 2004; Progress toward Interruption of Wild Poliovirus Transmission-Worldwide, 2006; Certification of Poliomyelitis Eradication- European Region, 2002; Tafuri et al., 2008; Dhole et al., 2009; Platt et al., 2014).

In the present study, therefore, the immunostatus of polio-vaccinated children and young adults (1-21 years old) living in Jeddah was investigated to ascertain their extent of protection against the virus, via estimation of circulating immunoglobulin G (IgG).

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**Table 1.** All Polio-ELISA results among Saudi and non-Saudi cases.

Nationality	Polio ELISA				Total
	Positive	Low Positive	Equivocal	Negative	
Saudi	192	12	16	8	228
Non Saudi	392	24	24	24	464
Total	584	36	40	32	692

## MATERIALS AND METHODS

### Sampling and experimental design

The present study was carried out within a 24-month period between January 2015 and December 2016. A total of 692 blood specimens were gathered from children admitted to the children wards of King Abdulaziz University Hospital-KAUH (Government) and International Medical Center Hospital-IMC (Private) in Jeddah City, Saudi Arabia for routine medical examination checkup. Each child's data was collected on a precoded inquiry form recording name, age, sex, nationality, and hospital entry reasons. It is worth mentioning that the consents of participants (the children) were acquired from the cases or their custodians earlier in the study and were revised and accepted by the Ethics committee of Clinical Microbiology Research Center, King Abdulaziz University. Of the 692 children and adults enrolled in the study, 228 children and young adults were Saudi residents. The remaining 464 screened individuals were children and young adults from Chad, Yeman, Pakistan, Somalia or other nationalities. The participants were categorized into the following groups based on their health or hospital records regarding anti-poliovirus vaccination:

(A) Immunocompetent:

Group I: Vaccinated by IPV at first  
Group II: Vaccinated by OPV at first

(B) Immunocompromised:

Tuberculosis (T.B.), diabetic, AIDS, and/ or congenital immunodeficiency patients.

(C) Control group:

50 healthy children who have completed all vaccination doses from a private hospital in Jeddah- IMC hospital were used as controls.

The inclusion criteria for children used in the study were that, they were children between 1 to 21 years, and have completed the anti-poliovirus vaccination program (3 doses+1booster dose). Exclusion measures were; new administration of immunoglobulin, blood products or immunosuppressive treatment.

### Specimen collection and handling

5 ml of venous blood samples was collected from each participant in plain tubes under complete aseptic conditions, following standard precautions. The samples were left to coagulate for some minutes and thereafter centrifuged at 3000 g for 5 min. The supernatant (serum) was later collected and stored at -20°C till use. Prior to use for analysis, the sera were diluted 1:101 with ready to-use sample diluent (e.g. 5 µl serum sample diluents).

### Detection of IgG in serum

Specific Polio immunoglobulin G antibody (IgG Ab) was quantified

by using ELISA kit (IMMUNOLAB GmbH, Otto-Hahn-Str. 16, D-34123 Kassel) for semiquantitative detection of IgG anti-Poliovirus in children's serum samples. The assay results were collated based on the instructions on the manufacturer's assay protocol.

### Statistical analysis

The results of the anti-poliovirus data for children from Saudi and non-Saudi were analyzed using the Student's t-test. Where  $p > 0.05$ , the compared means were considered as non-significantly different. Data computation was done using SPSS (version 20) for windows.

## RESULTS AND DISCUSSION

A total of 692 serum specimens were collected and tested from January 2015 to December 2016. 72 (10.4%) of these specimens were found to be seronegative for polio IgG and were regarded as non-immune children. Overall immune responders were 584 (84.4%) out of which 36 (5.2%) were low positive and hence their immunity against polio infection is doubtful. A total of 228 (32.95%) were Saudis, and 464 (67.05%) were non-Saudi individuals (Table 1). Non-Saudi (N.S.) seronegative subjects varied from 28 (6.03%) Yemani, 24 (5.17%) Somalian, 8 (1.72%) Afghani, 4 (0.86%) Indians, 3 (0.65%) Chadian, 2 (0.43%) Pakistanis; and 2 (0.43%) Nigerians (Table 1).

### Vaccination

The schedule for Polio vaccination in the government hospital in Jeddah was to give IPV in 2 months age, followed by OPV in 4, 6, 12, 18 months, and an OPV booster dose at the primary school entry, while, in the private hospital was as follows: IPV in 2, 4, 6 months age, followed by OPV in 12, 18 months, and an OPV booster dose at the primary school entry.

However, at the end of the study all vaccinations schedules were standardized among governmental and private hospitals in Jeddah, to give IPV in 2,4,6 with a drop of OPV in 6 months age, followed by OPV drop in 12, 18 months, and an OPV booster dose at the primary school entry.

The principal sequence of IPOL vaccine comprises of three 0.5 ml doses intramuscularly or subcutaneously administered, and it is advisable to be eight or more weeks separately and typically at ages 2, 4, and 6 to 18 months (Progress toward Interruption of Wild poliovirus Transmission-Worldwide, 2006). The vaccine should be

given more often than four weeks separately under no circumstances. The first immunization dose could be given at primary as six weeks of age. For this sequence, a booster dose of IPOL vaccine is given at 4 to 6 years of age (Progress toward Interruption of Wild poliovirus Transmission-Worldwide, 2006).

In recent United States studies, a combination of IPV and OPV was utilized which efficiently generated high neutralization titers (Ertem et al., 2000; Saleem et al., 2014).

## Conclusion

In this study, we found that a number of children were still seronegative for circulating IgG [72 (10.4%)], and 36 (5.2%) were low seropositive. Seronegative children are at high risk and vulnerable to Poliovirus; it is a strong indicator for failure of vaccination.

The study results also showed that 5.2% of the participants were weak responders to the vaccine with low seroconversion. Low seroconversion rate might be due to a number of reasons such as incomplete vaccination, simultaneous enteroviral infections, interloping between serotypes of OPV and deprived sanitization in water supply and sewage treatment (Faden et al., 1990; Vancelik et al., 2007; Tao et al., 2013, 2016). Accidental occupation and great inhabitation expansion level may be additional reasons for low seroconversion rates, in addition to illiteracy of parents.

On the other hand, poor maintenance in cold chain and, suboptimal habits of vaccine processing could result in low seropositivity (CDC, 2006). From the observed variations in responders status, it could be inferred that cultural differences may play a role in formation of attitudes and behaviours towards vaccination, as we found immune non-responders among non-Saudi varied from 28 (6.03%) among Yemani, 24 (5.17%) among Somalian, 8 (1.72%) among Afghani, 4 (0.86%) among Indians, 3 (0.65%) among Chadian, 2 (0.43%) among Pakistanis; to 2 (0.43%) among Nigerians (Table 1), even though all of them were from the government hospital in Jeddah.

Ultimately, the study data showed that Polio vaccination programme failed for 10.4% of studied children, and was insufficient for 5.2% of studied children. As Jeddah city remains a risk subject of the poliovirus importation from endemic regions, it is important to reach high immunization proportions to sustain current situation. If any country or its neighbors have a WPV importation recognition, then all health specialists need to quickly introduce additional immunization actions to limit the spread of WPV and achieve outbreaks interruption.

Based upon the present data, we recommend higher vaccination coverage and precise monitoring systems in polio-free countries. Evaluation of vaccination programmes should be implemented for early detection

of immuno negative disease-susceptible individuals.

## CONFLICT OF INTERESTS

The authors have not declared any conflict of interests

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