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Survey of poliovirus antibodies during the final stage of polio eradication in Egypt

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Abstract

Background: Egypt provides ideal conditions for poliovirus (PV) transmission (high population density, high contact rates and low sanitation and hygiene in some areas). Despite excellent program performance, wild poliovirus type 1 (PV1) continue to circulate in 2004. To investigate potential causes for the persistence, we conducted a serological study.
Methods: Seroprevalence surveys were conducted in "polio-endemic" regions (Greater Cairo and Upper Egypt) and in one control region (Lower Egypt) in December 2004. Sera collected from infants aged 6–11 months were tested for antibodies to poliovirus by neutralization assay.
Results: A total of 973 subjects were tested. Seroprevalence to PV type 1 (PV1), PV type 2 (PV2) and PV type 3 (PV3) was 99, 99 and 91%, respectively. Significant variation in PV3 seroprevalence was found (range: 76–100%). Region, density, maternal education, socioeconomic status (SES), stunting and diarrhea were significant risk factors for lower seroprevalence in the univariate analysis.
Conclusions: Our study suggested that uniformly high immunity levels (>96%) were required to interrupt PV1 transmission in the last remaining reservoirs (last PV1 was isolated in mid-January 2005 in Egypt). It further suggests substantial regional differences in OPV immunogenicity, with rural areas and low SES achieving the lowest seroprevalence to PV3.

Keywords: Vaccine; Poliomyelitis; Serosurvey

1. Background

Polio has probably been endemic in Egypt since ancient times. An Egyptian stele dated between 1403 and 1365 BC featuring a young man on crutches with a withered leg and the foot in a typical equivarus position is thought to represent the oldest picture of a patient with poliomyelitis [1].

Polio control efforts were initiated in Egypt when OPV vaccination was made compulsory in 1968 [2]. These control efforts led to precipitous declines in poliomyelitis incidence, and to the elimination of indigenous wild PV2 in Egypt sometime in the 1970s [3]. Following type 2 elimination, endemic type 2 circulating vaccine-derived poliovirus (cVDPV) circulated in Egypt from 1983 to 1993 [3]. From the mid-1970s, Egypt started a national program for polio elimination in which OPV was used during campaigns in practically every year, although not of the standard expected for an eradication effort. Following adoption of the goal of global poliomyelitis

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eradication in 1988 by the World Health Assembly [4], the global eradication strategies were implemented in Egypt starting in 1989 [2,5]. Surveillance for poliovirus in Egypt relies on two complementing systems: (1) acute flaccid paralysis (AFP) that has met the performance indicators since 2000 [6,7] and (2) environmental surveillance that relies on weekly sewage sample collection from 31 sites located representatively in Upper and Lower Egypt, as well as in Greater Cairo [8]. These systems provided strong evidence that the indigenous wild poliovirus strains had been eliminated in Egypt.

Implementation of the eradication strategies led to further decreases in the incidence of poliomyelitis, and the elimination of wild PV3, last detected in December 2000 [6,7]. However, the elimination of wild poliovirus type 1 (PV1 remained elusive. All isolated wild polioviruses from Egypt appear to be indigenous to the country [8]. Starting from 2002, the program performance further accelerated with procurement of oral poliovirus vaccine (OPV) from WHO-pre-qualified manufacturers, house-to-house administration of OPV, house markings and the introduction of finger markings with indelible ink of vaccinated children, and other program enhancements [9,10].

By 2002, Egypt was the only polio-endemic country that had both a high-performing routine immunization program achieving >90% OPV3 coverage, and excellent execution of supplemental immunization activities (SIAs; national immunization days [NIDs], sub-national immunization days [SNIDs] and mop-up campaigns), with high reported coverage (>90%) [6,7,10,11]. The mass vaccination campaigns were conducted with increasing frequency and quality. For example, both in 2003 and 2004, five NID rounds were conducted. Despite these efforts, wild PV1 continued to circulate in Egypt until January of 2005.

Part of the proposed explanation for the continued circulation was the high population density, contact rates and low sanitation and suboptimal hygiene in some areas. The population density is $\sim$1500/km^2 in the populated areas along the Nile Valley [12]. Serological studies in the pre-vaccine era reported that the average age of infection in Egypt was very low, suggesting a high force of poliovirus infection in the country [13].

To better understand the reasons PV1 continued to circulate in the two final reservoirs (each with its own genetic lineage of poliovirus) of Greater Cairo and Upper Egypt, seroprevalence surveys were conducted in December 2004. Following the study, wild PV1 was only isolated twice in Upper Egypt in 2005, in Fayoum on 10 January 2005 and in Sohag on 13 January 2005.

2. Methods

The objectives of the study were to determine whether there were regional differences in OPV immunogenicity, and if so, whether these differences could explain why some regions in Egypt remained PV1-endemic, and to determine if other factors affect seroprevalence, such as region, population density, socioeconomic status (SES), nutritional status and diarrhea. Immunity profiles of infants in areas with ongoing wild PV1 circulation in Upper Egypt (Assiut, Minia) and Greater Cairo were compared with areas in Lower Egypt (Beheira) without PV1 circulation (Fig. 1).

2.1. Sample size

PV3 was chosen as a marker of vaccine-induced seropositivity because there should be no natural immunity that would complicate interpretation, because PV3 circulation was interrupted 4 years earlier. Also, seropositivity for PV3 was expected from other OPV studies to be lower than for the other serotypes, providing a larger pool of seronegative children for analyzing risk factors. Sample size calculations were based on a projected 50% PV3 seroprevalence in the polio-endemic governorates and 70% in the control governorate, and an 80% probability of detecting a significant difference at the 5% level (two-tailed). The resulting sample size was 103 in each stratum, which was inflated to 120 to account for possible exclusions due to insufficient sera.

2.2. Eligibility criteria

Infants aged 6–11 months with consenting care-givers were eligible to participate, except those (a) born or residing outside of Egypt; (b) with serious acute illnesses requiring hospitalisation and (c) no written routine immunization records (clinic records, immunization cards, or birth certificates that included vaccination dates), with the exception that we included infants whose parents reported that the child had received no routine vaccinations at any clinic. We chose 6 months as the lower age limit to minimize the contribution of maternal antibody to seropositivity.

2.3. Site selection

Three governorates from Egypt's polio-endemic regions, Cairo, Assiut and Minia, were selected as polio-endemic study areas. Endemicity was defined as having at least one isolate from environmental (sewage) sampling positive for PV1 in 2004. Beheira governorate was chosen as the control site because it has had no PV1 detected from either environmental or AFP surveillance in the past 3 years. Enrollment was stratified by urban, semi-urban and rural population settings in Minia, Assiut and Beheira. Because Cairo is urban, enrollment was stratified by socioeconomic status by selecting three sites, each serving either a mainly low, medium or high SES population. A total of 37 HOs or RHUs were included in the study. For each stratum (urban, semi-urban, rural), the target number of children was distributed equally among the selected clinics.