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Interpreting the transmissibility of measles in two different post periods of supplementary immunization activities in Hubei, China

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ABSTRACT

Although evidence has shown that supplementary immunization activity (SIA) campaigns greatly reduce the incidence of measles, their effects on disease transmissibility have seldom been monitored. A great decrease in the number of cases may be a false signal of early success towards measles elimination to policy makers. By interpreting the transmissibility in two different post-SIA periods in Hubei, China, the current study showed sustained measles transmissions despite a reduced number of cases. Two population-based cross-sectional serological surveys of measles antibodies were conducted in Hubei province in mid-2010 and mid-2011 after the implementation of SIAs. Immunoglobulin G (IgG) antibodies against measles were measured by enzyme-linked immunosorbent assay (ELISA). Based on the estimated age-specific susceptibility levels, the effective reproduction number (R), a key indicator of disease transmissibility, was determined by the next generation matrix in transmission model. The results revealed an overall IgG seroprevalence of 88.0% (95% confidence interval [CI]: 85.6–90.4%) and 89.6% (95%CI: 88.0–91.2%), respectively, in the two different periods. Comparatively lower seroprevalence rates were observed among children less than 24 months of age and young adults 15 to 19 years of age in 2011. The Rs were 0.76 and 1.53 for the two study periods. In conclusion, even though the incidence was reduced to below 1/100,000 in both 2010 and 2011, the reproduction number in 2011 indicates a high risk for sustained measles transmission. This finding was potentially due to a lower seropositivity rate among young adults that had not been covered in the first SIA. Thus, implementation of SIA targeted to appropriate age groups is recommended. Regular monitoring of seroprevalence is also suggested to track disease transmissibility and to align SIA with the appropriate age groups.

1. Introduction

Measles, an infectious disease caused by the highly contagious measles viruses, contributes to childhood morbidity and mortality worldwide. Before vaccinations against measles were developed, 90% of children were infected with the virus before 15 years of age, corresponding to millions of lives worldwide lost to measles-induced diseases each year [1]. Since the initiation of large-scale vaccination programs from the 1920s to the 1960s, the incidence rate of measles has declined sharply. However, measles still tops the list of fatal infectious diseases worldwide, especially in developing countries, as the number of measles deaths worldwide reached a high of 134,200 cases in 2015 [29].

In China, the annual incidence has plummeted from 572.0 cases per 100,000 persons in 1960 to 7.6 cases per 100,000 persons in the 1990 with the aid of routine immunization. Yet, from 1995 the reported annual incidence started to rebound, peaking in 2005 with more than 120,000 reported cases [2,3]. In 2006, China endorsed the 2006–2012 National Action Plan, in which the Ministry of Health set a goal for the reported annual incidence rate to be less than 1 per 100,000 persons in 2012, with the aim of measles elimination. The measles immunization strategy was based on a routine immunization program, integrated with supplementary immunization activities (SIAs) while reinforcing disease surveillance, outbreak control, hospital-acquired infection control, and health improvement schemes.

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The measles-containing vaccine (MCV) was first introduced in China in 1966. Under the 1978 Expanded Program on Immunization (EPI) in China, the MCV was widely administered to all children. A second dose was further recommended in the 1986 EPI [33]. Currently, two doses of measles-mumps-rubella (MMR) vaccines are recommended in China, with the first and second doses administrated at eight and 18–24 months of ages, respectively. Despite high coverage rates of routine MMR vaccines, measles remained a common infectious disease in different provinces in China. Through age-specific immunization mop-up programs, tracking, and providing vaccinations to unvaccinated persons, SIAs can achieve high levels of immunity in all groups of citizens within a short period of time. In comparison, contingency vaccination plans offer vaccination services to a small designated group of citizens and may achieve vaccine coverage above 95% in the designated populations, thus providing better outbreak control. In 2009, public health officials in different provinces of China conducted SIAs in addition to the routine immunization program. Children and adults were targeted for an additional dose of the measles vaccine regardless of their previous history of measles vaccination. A nationwide SIA was further implemented in China in late 2010, resulting in a substantial decrease in measles incidences, from approximately 55,000 cases in 2009 to approximately 10,000 cases in 2011 [2]. In Beijing, the number of measles cases was reduced from more than 1000 cases in 2009 to 100 cases in 2011 [11]. Despite the early success, a resurgence of measles in 2013 occurred primarily due to sustained transmission among unvaccinated children [2]. Compared with developed countries in Europe and the Americas, China has a much higher population density and population mobility, which collectively constitute a higher risk of virus exposure for those susceptible to measles and subsequently aggravates the complexity and difficulty in eliminating measles in China. Therefore, the impact of past SIAs on disease transmissibility should be investigated in order to develop better preparedness plans for the implementation of vaccination campaigns, including scheduling of SIAs [4].

In the present study, we estimated the reproduction numbers, a measure of disease transmissibility, based on seroprevalence data from two different periods after the implementation of SIAs. The findings could help to assess the impact of previous SIAs and thus offer valuable advice for the planning of vaccination programs.

2. Material and methods

2.1. Setting and data collection

Hubei Province, located in the central China region, has a population of approximately 58 million people (Fig. 1). According to risk assessments from the Center for Disease Control and Prevention (CDC), six prefecture-level cities in the Hubei Province are at high risks for measles outbreaks [5]. The reported annual vaccination coverage for routine immunization was around 95%. Aiming to eliminate measles by 2012, Hubei Province has performed two SIAs between 2009 and 2012. The first SIA ran from September to November 2009, targeting all infants and children from eight months to 14 years of age. The SIA resulted in a 98% coverage rate. The second SIA, carried out in September 2010 and March 2011, additionally targeted children who were not vaccinated through the routine immunization program. Fig. 2 shows the measles epidemics in Hubei.

Two population-based cross-sectional serological surveys of measles antibodies were conducted in May 2010 and May 2011. In the first serosurvey, subjects were randomly selected from four major cities and towns. The random sampling in each of the areas was stratified into seven age groups as follows: <12 months,

Fig. 1. Hubei province, located in central China with 58 million populations.