Evaluation of the mass measles vaccination campaign in Guangdong Province, China

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1. Introduction

Measles is a highly contagious vaccine-preventable respiratory disease caused by the measles virus. It is still a common and fatal disease, and a leading cause of death in children in many developing countries. More than 95% of measles deaths have been shown to occur in countries with low per capita incomes and weak health infrastructure. Between 2000 and 2008, measles vaccination resulted in a 78% drop in measles deaths worldwide, from an estimated 733,000 deaths in 2000 to 164,000 in 2008. Vaccinating nearly 700 million children aged 9 months to 14 years against measles, through large-scale campaigns and increased routine immunization coverage, has prevented an estimated 4.3 million measles deaths in less than a decade. Twenty-four of the 37 countries and areas in the World Health Organization (WHO) Western Pacific Region have either achieved or nearly achieved the measles elimination goal. Nonetheless, 131,441 confirmed measles cases were reported from China in 2008.

During the period 1951–1965, prior to the use of the measles vaccine in China, measles incidence fluctuated between 300 and 1400 cases per 100,000 population per year, and mortality rates were around 10 cases per 100,000 population per year, with the highest reported being 39.7 per 100,000 in 1959. Measles incidence decreased dramatically following widespread use of the measles vaccine in 1965 and the integration of the measles vaccine into the national Expanded Programme on Immunization (EPI) in 1978. From 1991 to 1995, the average annual measles incidence was 9 cases per 100,000 population, which decreased to 5.7 per 100,000 in 1996–2000. From 2003 to 2006, measles incidence varied from 5.7 to 9.5 per 100,000. In 2008, an incidence of 10 cases per 100,000 population was reported, the highest since 1993. Following the implementation of measles vaccination campaigns in nine provinces of China in 2009, measles incidence decreased to 4 cases per 100,000 population per year. China, which successfully eradicated wild-type poliovirus in 1994, has now established a goal for measles elimination by 2012.

Guangdong Province, with 21 prefectural cities, is located in southern China, covering an area of 179,766 square kilometers. The Province has a population of 110 million, which includes 79 million permanent residents and 31 million migrants who have lived in...
Guangdong Province for over 6 months. In Guangdong Province, the reported measles incidence was between 45 and 1407 cases per 100 000 population per year for the 14 years before the introduction of the measles vaccine in 1965. Over the next 35 years, measles incidence decreased dramatically from 1407 cases per 100 000 population in 1965, to 426 cases per 100 000 population in 1979 and 1.3 per 100 000 population in 1999. With the influx of migrant workers due to increased economic development, the measles incidence increased slightly from 2000 to 2003. From 2004 to 2007, the incidence continued to rise, reaching a national high of 21.2 per 100 000 population in 2007. Some densely populated cities located in the Pearl River Delta (PRD) area, where large mobile populations dwell, such as the cities of Guangzhou and Shenzhen, have had the highest measles incidences in Guangdong Province. In 2007, in order to control the endemcity of the measles virus, we carried out a variety of measures such as supplemental immunization activities in the PRD area populated largely by migrant workers and their children. However the impact of these activities was limited, as the measles incidence remained high at 16.1 per 100 000 population in 2008. Therefore, the Government of Guangdong Province decided to conduct a mass measles vaccination campaign in 2009. In order to avoid a failure of the mass vaccination campaign, as has happened in other countries and regions, we carefully evaluated the campaign in Guangdong Province to acquire experience and lessons that would be of use for similar activities in the future.

2. Materials and methods

2.1. Organization and implementation of the campaign

The Guangdong Provincial Development and Reform Commission, Department of Health, Department of Education, Department of Finance, and Food and Drug Administration Bureau set up a ‘Guangdong Provincial Coordination Group for the Expanded Program on Immunization’, responsible for the coordination of the measles vaccination campaign in each sector. The Provincial Department of Health developed guidelines for the measles vaccination campaign. These included information on the target population, the general campaign strategy, approaches to vaccine distribution and delivery, the location of temporary vaccination sites, the supervision of campaign implementation, and the reporting and treatment of adverse events following immunization (AEFI). The Provincial Department of Education arranged the vaccination activities in kindergartens and schools, and the Provincial Department of Finance provided 127 million Yuan for the campaign. A total of 68 341 medical staff were trained to take part in the vaccination activities at 5540 regular vaccination sites and 38 569 temporary vaccination sites; 7819 healthcare staff were sent out to conduct on-site supervision of the campaign.

The major news media and television stations publicized the campaign and other topics related to measles vaccination. A 15-minute advertisement on the campaign was shown on two provincial television programs during prime evening viewing time. The Guangdong branch of the China Mobile Communications Corporation sent out 11 million messages to inform provincial residents of the campaign. There were 28 million flyers disseminated, and 400 000 posters and 28 957 streamers put up.

Because of the limited supply of measles vaccine, the measles vaccination campaign had to be implemented in two phases. The first phase of the campaign was conducted in 12 cities in March 2009, and the second phase was undertaken in the remaining nine cities in April 2009.

2.2. Target population

The target population was all children aged 8 months to 14 years who were living in Guangdong Province, regardless of their residence status, vaccination or disease history. Data published in 2008 from the Statistics Bureau indicated that there was a total population of 94 490 000 in Guangdong Province in 2007, including 18 992 490 children aged under 15 years. Door-to-door investigations conducted prior to the campaign indicated that there were 20 437 255 children aged 8 months to 14 years. The extra number of children was mostly made up of migrant people from other provinces.

2.3. Vaccination

One dose (0.5-ml) of measles live attenuated vaccine was injected into the target child after obtaining parental or guardian consent. The vaccine was produced by the Lanzhou and Wuhan Biological Products Institutes. The measles vaccine and the disposable syringes were purchased through public tender.

2.4. Rapid coverage assessment

No sooner had the vaccination activity finished in a city than the provincial supervisors were instructed to conduct the rapid coverage assessment (RCA) using a supervisory assessment tool developed by the WHO. A stratified multi-stage probability proportional to size cluster sampling was used in selecting the assessment population. Two counties (or districts) in a city were selected randomly; one town (or street) was selected randomly from each county (district); one village (community), one school (kindergarten), and one market were selected randomly from the town (street). Then, 30 children were selected randomly from the village, school, and market, respectively. A sample of 90 children in each city was then checked to determine if they had been vaccinated during the campaign. If two or more children were found to be unimmunized, but without contraindications, the city was requested to conduct repeated ‘mop-ups’ until reassessment showed that the necessary standard had been met.

2.5. Data collection

Prior to the campaign a thorough investigation was conducted to find and register all children aged 8 months to 14 years. Demographic data were acquired from the Guangdong Provincial Annual Statistic Report 2008.

Data on the measles campaign were collected by the municipal Centers for Disease Control and Prevention (CDC) using standardized tools. Information to be collected included number of target children, vaccinated children, social mobilization, staff involved, temporary vaccination sites, and reported AEFI.

A suspected measles case is defined as any person with fever above 38 °C and a maculopapular rash accompanied by cough, coryza, or conjunctivitis. Suspected measles cases are confirmed in one of three ways: a laboratory-confirmed case is one that tests positive for measles-specific immunoglobulin M (IgM) antibodies using a diagnostic kit for IgM antibody to measles virus (Capture-ELISA; Zuhai S.E.Z Haitai Biological Pharmaceuticals Co., Ltd, Guangdong, China); an epidemiologically confirmed case is one who has evidence of exposure to a confirmed measles case within the incubation period (21 days); and a clinically confirmed case is one that meets the clinical case definition despite the absence of a blood test and a history of exposure. All suspected measles cases should be tested for rubella-specific IgM if the measles-specific IgM is negative. Suspected cases with negative laboratory tests for
measles-specific IgM or positive tests for rubella-specific IgM are discarded as non-measles cases.

Case-based measles surveillance, in which any suspected measles case must be reported and investigated and specimens collected, has been conducted in China since 1998. Along with the progress of the campaign, any measles case would be reported to the internet-based National Notifiable Infectious Disease Reporting System.

2.6. Statistical analysis

All data were double-entered into a pre-designed database. Statistical analysis was carried out using the Statistical Package for the Social Sciences (SPSS 13.0; SPSS, Chicago, IL, USA). The Pearson Chi-square test was used to test for differences between the awareness rates and vaccination coverage before and after the campaign. A \( p \)-value of less than 0.05 was considered significant.

2.7. Serological surveillance

The Guangdong Provincial CDC conducted serological surveys of measles after the campaign in 2009. According to the 2008 population census for Guangdong Province, the minimum sample size required for the current study was calculated to be 1260 with a 1% error and 90% confidence interval. In the first stage of sampling, the province was divided into three strata, i.e., the eastern area, western area, and PRD area. Each stratum included seven cities. In the second stage of sampling, six counties were selected from each stratum. Towns or streets were assigned as clusters (sampling units). The list of all towns or streets with their populations was obtained from local governments, and 30 clusters were selected by systematic sampling method from a random start in each county. The target sample size of 1260 was allocated to the six counties. It was planned to select seven children from each cluster. Since some children were absent or reluctant to join the survey, 1205 children were interviewed; serum samples were collected from these children and they were divided into five age groups (1–2, 3–4, 5–6, 7–9, and 10–14 years). A questionnaire was used to collect demographic information including age, sex, previous history of measles, and vaccination in the campaign.

All serum samples were sent to the laboratory of the Guangdong Province CDC and tested for measles IgG antibody using a commercial kit (SERION ELISA classic measles virus IgG, Behring, Germany). The antibody level was considered positive when the geometric mean titer (GMT) reached 1:200 mIU/ml.

3. Results

3.1. Awareness rate

Before the campaign, 676 residents were randomly selected and interviewed. After the campaign, 2571 residents were randomly selected and interviewed. The questions asked included “Are you aware of the measles vaccination campaign?” and “How do you know about the campaign?”

The awareness rate of residents was increased from 91.86% (621/676) before comprehensive mobilization to 97.10% (3153/3247) afterwards. The difference in the awareness rates was statistically significant (Chi-square = 42.06, \( p < 0.01 \)). Of the residents investigated, 39.3% were aware of the campaign through flyers, 22.2% through hearing from doctors, 19.2% through television broadcasts, 6.6% by home visits, 4.4% through posters and banners, 4.3% through mobile phone messages, 2.1% through newspapers, and 1.9% through other means.

3.2. Vaccination coverage

Among 20 437 255 eligible children, i.e., those aged between 8 months and 14 years, without any serious illness or contraindications to measles vaccine, and with parental or guardian consent, screened by door-to-door investigation before the campaign, 19 952 519 received the measles vaccine inoculation during the campaign period, reaching a coverage of 98.09%. The vaccination coverage of children who were not local residents was similar to that of children who were local residents. The supervisors from the provincial CDC conducted rapid coverage assessments in 42 counties (districts) of 21 cities. These assessments showed that 7640 migrant children were vaccinated among the 7850 surveyed, with a vaccination coverage of 97.32%.

The vaccination coverage of migrant children increased significantly from 67.10% before the campaign to 97.32% after the campaign (Chi-square = 2452.0, \( p < 0.01 \)) (Table 1). The PRD area was more prosperous and occupied by more migrant children, while the non-PRD area was less prosperous and occupied by fewer migrant children. The vaccination coverage increased significantly both in the PRD area, from 65.73% to 97.58% (Chi-square = 2308.2, \( p < 0.01 \)), and in the non-PRD area, from 76.17% to 95.62% (Chi-square = 160.6, \( p < 0.01 \)) after the campaign (Table 1).

3.3. Adverse events following immunization (AEFI)

During the campaign, AEFI were reported to the provincial CDC on a daily basis. After investigation and diagnosis, there were 197 cases of vaccination-related events for a rate of 0.99 per million doses of measles vaccine. No collective hysteria or deaths related to vaccination reactions were reported (Table 2).

3.4. Measles incidence

During the period of May to December 2009 following the measles vaccination campaign, 720 measles cases were reported in Guangdong Province, while 10 344 measles cases were reported during the same time-period in 2008. The measles incidence decreased by 93%. No case of death was reported in 2009. The incidence rates of measles by month from 2007 to 2009 in Guangdong are shown in Figure 1.

<table>
<thead>
<tr>
<th>Cities</th>
<th>No. of children surveyed</th>
<th>Vaccination before the campaign</th>
<th>Vaccination after the campaign</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>No. of children vaccinated</td>
<td>Coverage (%)</td>
<td>No. of children vaccinated</td>
</tr>
<tr>
<td>In Pearl River Delta area</td>
<td>6822</td>
<td>4484</td>
<td>65.73</td>
</tr>
<tr>
<td>In non-Pearl River Delta area</td>
<td>1028</td>
<td>783</td>
<td>76.17</td>
</tr>
<tr>
<td>Total</td>
<td>7850</td>
<td>5267</td>
<td>67.10</td>
</tr>
</tbody>
</table>

<sup>a</sup> Comparison between the vaccination coverage of migrant children before and after the campaign in the Pearl River Delta area (Chi-square = 2308.2, \( p < 0.01 \)).

<sup>b</sup> Comparison between the vaccination coverage of migrant children before and after the campaign in the non-Pearl River Delta area (Chi-square = 160.6, \( p < 0.01 \)).

<sup>c</sup> Comparison between the vaccination coverage of migrant children before and after the campaign in Guangdong Province (Chi-square = 2452.0, \( p < 0.01 \)).
Table 2
Reported adverse events after the mass measles vaccination campaign in 2009, Guangdong Province, China

<table>
<thead>
<tr>
<th>Adverse events</th>
<th>Number of cases</th>
<th>Incidence (per million doses)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Anaphylactic rash</td>
<td>166</td>
<td>0.83</td>
</tr>
<tr>
<td>Angioedema</td>
<td>6</td>
<td>0.02</td>
</tr>
<tr>
<td>Febrile convulsion</td>
<td>5</td>
<td>0.03</td>
</tr>
<tr>
<td>Thrombocytolytic purpura</td>
<td>5</td>
<td>0.03</td>
</tr>
<tr>
<td>Anaphylactic purpura</td>
<td>4</td>
<td>0.03</td>
</tr>
<tr>
<td>Hives</td>
<td>4</td>
<td>0.03</td>
</tr>
<tr>
<td>Anaphylactic shock</td>
<td>3</td>
<td>0.02</td>
</tr>
<tr>
<td>Other anaphylactic reaction</td>
<td>1</td>
<td>0.02</td>
</tr>
<tr>
<td>Total</td>
<td>197</td>
<td>0.99</td>
</tr>
</tbody>
</table>

Table 3
Serological surveillance after the mass measles vaccination campaign in 2009, Guangdong Province, China

<table>
<thead>
<tr>
<th>Age, years</th>
<th>Number of children selected</th>
<th>GMT (mIU/ml)</th>
<th>Positive number (≥1:200 mIU/ml)</th>
<th>Positive rate (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1–2</td>
<td>300</td>
<td>2420.54</td>
<td>292</td>
<td>97.33</td>
</tr>
<tr>
<td>3–4</td>
<td>316</td>
<td>2502.92</td>
<td>312</td>
<td>98.73</td>
</tr>
<tr>
<td>5–6</td>
<td>317</td>
<td>1678.19</td>
<td>315</td>
<td>99.37</td>
</tr>
<tr>
<td>7–9</td>
<td>150</td>
<td>1215.68</td>
<td>148</td>
<td>98.67</td>
</tr>
<tr>
<td>10–14</td>
<td>122</td>
<td>1666.24</td>
<td>121</td>
<td>99.18</td>
</tr>
<tr>
<td>Total</td>
<td>1205</td>
<td>1959.87</td>
<td>1188</td>
<td>98.59</td>
</tr>
</tbody>
</table>

GMT, geometric mean titer.

3.5. Serological measles IgG level after the campaign

After the campaign, a total of 1083 serum samples were randomly collected from children aged 2 to 14 years. The GMT of measles virus antibody was 5870.33 mIU/ml. The antibody positive rate reached over 95% (Table 3).

4. Discussion

Although measles is highly infectious, high quality mass vaccination can rapidly increase herd immunity and reduce measles transmission. Because of the shortage of measles vaccine, the campaign reported here was conducted over the course of 1 month, a longer period of time than the WHO’s recommendation that implementation of a measles campaign is better carried out over the course of 1 to 2 weeks. In fact, there was a significant decrease in the incidence of measles after the campaign (after April of 2009), the period that is the seasonal peak for measles incidence in Guangdong Province. This demonstrated that the implementation of the campaign was successful even though the time taken to carry out the vaccinations was longer than 2 weeks. The impact of the campaign on measles incidence is similar to that reported after mass measles vaccination campaigns in other areas of China and in other countries. Moreover, the results of serological surveillance in 2009 after the vaccination campaign showed that the measles virus antibody positive rates of children aged less than 15 years had reached over 95%. We think that the measles virus antibody level could partly reflect the effect of the campaign in 2009, indicating the increase in immunity in children aged less than 15 years. Since the target population in whom the serological surveillance was conducted did not include adults aged over 15 years, it is uncertain if the measles virus antibody positive rates of the whole population reached over 95% or not. It is necessary to achieve and maintain high herd immunity in order to interrupt the endemic transmission of measles virus and attain the goal of eliminating measles. Therefore, we plan to conduct serological surveillance for the whole population and make certain which age groups need supplement immunization in the near future.

A number of experiences were gained and lessons learned from this mass vaccination campaign, which successfully vaccinated nearly 20 million children in Guangdong Province. The activity showed the critical importance of government leadership, leading to the successful collaboration of many government departments. The Vice Provincial Governor of Guangdong and 15 mayors attended the campaign opening ceremony and emphasized the importance of careful implementation of the campaign.

Publicizing the campaign through a variety of modalities was also important. These activities allowed us to increase public knowledge. An investigation conducted prior to and during the campaign showed that the rates of awareness of the measles vaccine campaign increased from 91.86% to 97.10%. This investigation also showed that flyers, information from public health
doctors, and the use of television programs were particularly effective methods for reaching the public.

Prior to the campaign, children in the target age group for vaccination were pre-registered through door-to-door visits. This approach allowed us to increase the number of children vaccinated to the utmost extent. Many of these children were not local permanent residents, but they were also registered for vaccination. This pre-registration during the campaign allowed more migrant children to be enrolled into the routine immunization program.

We also noted the importance of adequately training staff and ensuring safe injections. A total of 68,341 medical staff were trained to work at 5,540 fixed sites and 38,569 mobile sites. We divided the mobile sites into four areas: registration, injections, observation, and treatment as required for vaccine reactions. These areas were separated by partitions from each other. Precautions such as education prior to the campaign and minimizing the number of students in the vaccination room at the same time were also taken, and doctors and teachers were trained, in order to avoid the occurrence of mass hysteria during the school-based vaccination sessions.

We also communicated actively with the media and conducted media surveillance for this campaign. Initially, rumors that some serious reactions might happen after the vaccination impeded the progress of the campaign. Some adverse reactions to vaccination were reported and exaggerated by the mass media, thus increasing the people’s misgivings about the vaccination. Daily media surveillance helped us to understand the people’s concerns as quickly as possible, and the responses to these concerns by the medical experts could, in turn, be publicized through the mass media.

Monitoring and supervision during the campaign helped to ensure high quality coverage and prevent the re-emergence of measles after the campaign. It is also important to conduct rapid coverage monitoring during a campaign to identify areas with inadequate coverage. Despite our efforts, some children remained unvaccinated for a variety of reasons. We noticed that some measles cases occurred among the target age group in children who had not received the measles vaccine inoculation during the campaign. The main reason for not being vaccinated was that the children were suffering from other medical conditions during the campaign and did not receive the vaccination thereafter. The other reasons included parents being busy at work, ignorance of the campaign, or not being available at that time. Therefore, we should continue to monitor and identify the unvaccinated children after the campaign. In order to maximize the coverage of measles vaccination, routine measles vaccination should be offered to children regardless of their residence status.

Political and public support are necessary for successful measles elimination activities, especially in a densely populated urban environment. It was reported that the migration of children between two cities played a major role in the failure of a campaign to interrupt measles transmission. Therefore, the emphasis on the vaccination of non-resident children should be a high priority in countries or regions where much migration occurs. This mass measles vaccination campaign increased the level of herd immunity to measles and decreased the number of unvaccinated children, particularly among the non-resident population. The comprehensive mobilization and screening of target children with the support of government departments were critical to the success of the campaign. This campaign also enhanced the public’s consciousness and acceptance of vaccination. The experiences from this campaign will be valuable in achieving the goal of measles elimination by 2012.

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References