Mumps disease in Beijing in the era of two-dose vaccination policy, 2005–2016

Rui Ma, Li Lu *, Tao Zhou, Jingbin Pan, Meng Chen, Xinghuo Pang

EPI Department, Beijing Center for Disease Control and Prevention, Beijing 100013, PR China

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ABSTRACT

Background: Since the introduction of mumps-containing vaccines (MuCV) in 1995 in Beijing, two-dose MuCV vaccination policy has been used, with the 1st and 2nd doses given at 18 months and 6 years of age, respectively.

Methods: Mumps epidemiology during 2005–2016 was described using surveillance data. Vaccine effectiveness (VE) of MuCV against disease was estimated for cases born during 2002–2009 and reported in 2016. VE against complications was estimated for all cases. MuCV coverage was estimated for children born during 1999–2015 using data from Beijing Immunization Information System.

Results: Overall mumps incidence decreased from 30.38/100,000 persons in 2005 to 10.26/100,000 persons in 2016. Incidence declines in children aged <15 years. No significant incidence change occurred in adults aged ≥20 years. Incidence in persons aged 15–19 years increased by 132.73% in 2012 when compared with in 2005. Rates of meningitis/encephalitis, orchitis, and other complications among cases decreased during 2005–2016. The majority (97%) of outbreaks occurred in schools. Total number of outbreaks and average outbreak size decreased during 2005–2016. Among outbreak-related cases, 69.54%, 29.67% and 0.79% had received 0 dose, 1dose and 2 doses of MuCV, respectively. Coverage of the 1st MuCV dose at 2–5 years of age increased by 42.75% during 2005–2016. Coverage of the 2nd MuCV dose at 6–14 years of age increased by 12.87% during 2013–2016. Overall VE estimates of MuCV against mumps disease were 74.51% (95% CI: 65.57–81.34%) for 1 dose and 83.16% (95% CI: 78.60–86.31%) for 2 doses. Both VE estimates increased by birth cohorts. VE estimate against complications for 2-dose MuCV was higher than for 1 dose.

Conclusions: Increasing MuCV coverage achieved declining mumps incidence and complication rate. Current epidemiology supported 2-dose MuCV vaccination policy. The incidence rise in persons aged 15–19 years in 2012 and waning immunity for the 2nd MuCV dose merited close follow-up.

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1. Introduction

Mumps is a vaccine-preventable disease caused by mumps virus, which usually occurs in childhood especially in the pre-vaccine era [1]. Beijing began mumps vaccination in 1995 and 2 mumps-containing vaccines (MuCV) were available: domestic single antigen mumps vaccine (S79 strain), and the combined measles, mumps, and rubella vaccine (MMR) of Merk (Jery1-Lynn

vaccine strain). The two-dose MuCV vaccination schedule has been in practice for children under 15 years of age in Beijing since 1995, with the 1st and 2nd MuCV doses given at 18 months and 6 years of age, respectively. In 2006, domestic MMR (S79 strain) was introduced into the Expanded Immunization Program (EPI). Since then domestic single antigen mumps vaccine and Merk's MMR have been no longer in use due to their similar immunogenicity as domestic MMR [2,3].

In 1989, mumps became a notifiable disease in China. Since 2005, all mumps cases have been mandatorily reported via the National Notifiable Disease Reporting System (NNDRS), a web-based computerized reporting system. We used data from NNDRS and Beijing Immunization Information System (BIIS) to describe mumps epidemiology and MuCV vaccination coverage from 2005 to 2016.

2. Material and methods

2.1. Description of Beijing

Beijing, the capital of China, is the second most populous city in the country. Based on the annual census data from Beijing municipal Bureau of Statistics, the population increased by 45.51% from 14.92 million in 2005 to 21.71 million in 2016. Out of the total population in 2016, 2.24 million (10.31%) aged 0–14 years, 16.01 million (73.68%) aged 15–59 years and 3.48 million (16.01%) aged 60 years or over. Average per capita disposable income in Beijing reached about 52,530 yuan (8081.54 dollars) in 2016, ranking the second highest among China's 31 provincial level regions.

2.2. Case and outbreak definitions

For surveillance purpose, mumps is defined as a clinically diagnosed illness. According to the diagnostic criteria for mumps approved by the Ministry of Health of China in 2007 [4], we defined a mumps case as a person of acute onset of unilateral or bilateral swelling of the parotid gland or other salivary gland characterized by any of the following, which could not be explained by another more likely diagnosis: (1) fever, headache, weakness, loss of appetite; (2) orchitis; (3) pancreatitis; (4) encephalitis and/or aseptic meningitis. In Beijing, a mumps outbreak is defined as the occurrence of ≥5 mumps cases in a community, school, company or other setting within 14 days [5].

2.3. Mumps surveillance

For each reported mumps case in NNDRS, we conducted a field investigation to collect information on demographic characteristics (birthday, gender, and occupation), clinical presentations, onset date of symptoms, MuCV immunization status and contacts. The vaccination history of each case was determined using his/her written immunization history (the immunization certificate kept by the vaccine recipient or the guardian, or the immunization record kept by the immunization clinic). Immunization certificates recorded more vaccine doses than immunization records [6,7]. So based on MOH's guideline [8] and technological standards for EPI in Beijing [5], the immunization history of a mumps case was assessed firstly from the certificate. If no certificate was available, the immunization record kept by clinics was used. That immunization record referred to the immunization card kept by clinics for a case born before 1999 and the record in BIIS for a case born in or after 1999.

To take into account the immunization schedule of MuCV in Beijing, mumps cases were categorized into 5 age groups based on the age of disease onset: <1, 1–5, 6–14, 15–19, and ≥20 years. We used the annual census data from Beijing municipal Bureau of Statistics as denominators to calculate mumps incidence in Beijing.

2.4. MuCV vaccination coverage

All MuCV were given to the target children by healthcare workers in special immunization clinics. In 2005, MuCV vaccination (including vaccine and administration service) was paid by recipients or guardians. Since 2006, MuCV vaccination was given free of charge. And children without any contradictions to MuCV were required to get vaccinated based on the schedule. After administration of each vaccine dose, healthcare workers were required to record the vaccine, vaccine dose and vaccination date both on the immunization certificate and on the immunization record (immunization card/BIIS system).

BIIS is a web-based computerized system, which was set up in 2008. It keeps track of immunization histories (including vaccine, vaccine dose, vaccination date) for each child. When it was put into practice, the retrospective data from the children born in 1999 were required to be entered into the system, according to their immunization cards kept by clinics. The coverage of BIIS among the children born in or after 1999 was reported to be above 98% [6]. Data on MuCV vaccination coverage were obtained from BIIS. We used the children enrolled in BIIS in the end of 2016 to define birth cohorts from 1999 to 2015. We calculated MuCV vaccination coverage by using the cumulative number of children who had received MuCV till the end of each year divided by the total number of children in the corresponding birth cohort without excluding those with prior mumps disease history because this information was unavailable. For age-specific MuCV coverage, age was calculated up to the end of the corresponding year.

2.5. Statistical analyses

Vaccine effectiveness (VE) of MuCV against mumps disease was estimated by using the screening method [9]. Using that method, VE is estimated by comparing the proportion of cases vaccinated (PCV) with the proportion of the population vaccinated (PPV). Only cases eligible to receive 2 doses of MuCV before disease onset were included. We selected the mumps cases by using the following criteria: (1) having known immunization status; (2) born during 2002–2009; (3) reported in 2016. The criteria were used to ensure that PPV could be obtained from BIIS and most cases had received their MuCV vaccination at the same age. When estimating VE for 2 doses, those who had only received 1 dose were excluded. Similarly, those with 2 doses were excluded when estimating VE for 1 dose [10,11]. To estimate the trend of VE by intervals since vaccination, cases were further divided into 4 subgroups based on birth cohorts: 2002–2003, 2004–2005, 2006–2007, 2008–2009. The overall VE and VE within each subgroup was estimated.

Chi-squared test was used to evaluate the distribution of categorical variables. Logistic regressions were used to estimate VE of MuCV against mumps disease [10] and complications [12] for cases with known immunization status. Statistical significance was defined as $P < 0.05$. All analyses were conducted using R version 3.4.4.

3. Results

3.1. Mumps incidence

A total of 39,218 mumps cases occurred during 2005–2016. Despite a slight rebound in 2012, the annual number of mumps cases decreased by 50.89% from 4535 in 2005 to 2227 in 2016. And the overall incidence decreased by 66.23% from 30.38 per 100,000 population in 2005 to 10.26 per 100,000 population in 2016 (Fig. 1).

3.2. Demographic characteristics of mumps cases

Mumps incidence was highest among children aged 1–5 years and lowest among adults aged ≥ 20 years. The incidence among the children aged less than 1 year, 1–5 years and 6–14 years decreased by 93.38%, 68.35% and 73.64%, respectively, from 2005 to 2016. The incidence among the population aged 15–19 years significantly increased in 2012, which was 132.73% higher than that in 2005. There was no significant change in the incidence among adults aged ≥20 years during 2005–2016 (Fig. 2).

Of the 39,218 cases, 24,050 (61.32%) were male. Most (68.76%) cases were students in kindergartens and schools. That proportion