



## An expensive adult measles outbreak and response in office buildings during the era of accelerated measles elimination, Beijing, China



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### ABSTRACT

**Background:** Few measles outbreaks among adults are reported in China, and outbreak response costs are seldom documented. We report an adult measles outbreak and response in 4 linked office buildings in Beijing and its associated costs.

**Method:** The World Health Organization measles case definitions were used to determine suspected and confirmed measles cases. Surveillance data were used to describe the outbreak, and records and interviews of response staff were used to describe the response. Costs were determined by use of retrospective surveys of cases, review of records, and interviews of staff.

**Results:** The outbreak lasted 19 days, and involved 22 cases aged 23–49 years. Nineteen cases had a local household registration. All cases were employed by 8 companies in 4 linked office buildings. Among the 22 cases, 8 had temperature less than 38.5 degree, 18 had no Koplik spots and none had complications or hospitalizations. A total of 7930 contacts were identified, and of these, 6869 were employees in the office buildings. All the child contacts aged 8 months–14 years had been up-to-date for measles-containing vaccine (MCV); no adult could document their vaccination or measles history. Of contacts, about 96% were offered post-exposure vaccination. The total household costs were \$13,298, or \$605 per case. Control costs were \$384,594, or \$17,481 per case. Involved companies paid for 90.7% of control costs.

**Conclusion:** Office buildings provide a mechanism for measles transmission. Timely control activities were challenged by the highly infectious nature of measles and mild presentations of cases. The outbreak response was very costly. Financial support by involved companies can provide needed resources for outbreak management.

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## 1. Introduction

The introduction of measles-containing vaccine (MCV) in China in 1965 has led to a dramatic decline in measles cases. With improvement of routine immunization among children in Beijing, adults have accounted for an increasing proportion of measles cases [1,2]. Data from the infectious disease surveillance system of Beijing Center for Disease Control and Prevention (CDC) showed that the proportion of the measles cases among individuals 15–49 years of age increased from 57.7% in 2011 to 71.4% in 2014.

And the measles incidence for this age group increased almost by 27 times from 4.5 per million in 2011 to 124.2 per million in 2014. A 2012 measles IgG serosurvey in Beijing showed that immunity among adults 15–49 years old was approximately 85% [3], which is lower than the herd immunity threshold of 95% [4] needed to eliminate measles. Due to inadequate immunity among adults, transmission of measles virus is likely to occur in settings where adults congregate. In fact, between 2011 and 2014, 93.8% (61/65) of reported adult measles outbreaks in Beijing occurred in workplaces (unpublished data from Beijing CDC).

Standard operating procedures for response to adult measles outbreaks, including contact tracing, case isolation, and post-exposure prophylaxis, are not available in China, and few adult outbreaks have been reported. Although there have been studies in other countries on outbreak-response costs [5–13], no formal

*Abbreviations:* MCV, measles containing vaccine; CDC, Center for Disease Control and Prevention; RT, response team.

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costing studies of a measles outbreak from China has been documented, to our knowledge.

In January 2015, Beijing CDC responded to a large measles outbreak among adults in 4 linked office buildings. We report the outbreak epidemiology and control activities and describe the economic impact on cases and their households, health sectors, workplaces, and communities.

## 2. Methods

### 2.1. Case and outbreak definitions

We defined a suspected measles case as a person meeting the World Health Organization (WHO) clinical case definition for measles (fever, generalized maculopapular rash, and cough, coryza, or conjunctivitis [14]). Confirmed cases had laboratory evidence of infection - positive serology for measles immunoglobulin M (IgM), and/or presence of measles RNA.

Based on China's national measles surveillance guidelines [15], an outbreak was defined as the occurrence of 2 or more measles cases in a group setting (community, school, company, building) within 10 days. During the outbreak, any measles case with an epidemiological link with the reported cases would be identified as an outbreak case. And the outbreak is declared over when no epidemiologically linked case occurs within 21 days from the onset of the last known measles case.

### 2.2. Controlling measures

Response teams (RTs) were established in each involved company in the buildings, and in each involved community and health care setting.

#### 2.2.1. Case report and investigation

Every suspected measles case was reported to the infectious disease surveillance system of Beijing CDC right after the diagnosis was made, based on China's national measles surveillance guidelines [15]. For each suspected measles case, an investigation was conducted to collect information on measles-like symptoms, MCV immunization histories, travel history, and contacts. Serum specimens and throat swabs were obtained and sent to Beijing's measles laboratory network for confirmation by serology and viral testing using previously described methodology [12]. If IgM results from serum collected 0–3 days after rash onset and RNA results from throat swabs were both negative, another serum specimen was collected 4–28 days from rash onset for IgM testing to exclude the possibility of a false negative due to collecting the first specimen too early [4].

#### 2.2.2. Contact tracing and surveillance

Initially, only employees from the companies reporting cases were considered contacts; following declaration of the outbreak, all employees in the 4 buildings were considered contacts. Health-care personnel (physicians, nurses, support staff, and trainees) in hospital clinics visited by cases during their infectious period were also considered contacts. In communities that the cases resided in, individuals who might have been exposed to measles during community activities were considered contacts.

Each contact was queried daily by RTs for the occurrence of fever or rash until 21 days from the last date of possible exposure. Each suspected measles case was isolated until the end of his or her infectious period or was confirmed not to have measles by laboratory tests. Once the outbreak was declared, any new fever or rash case was isolated until recovered. We used the infectious disease surveillance system to identify suspected measles cases in the

communities where the 4 buildings were located or where the reported cases lived.

#### 2.2.3. Postexposure vaccination

People born before 1965 in China are considered immune to measles due to measles infection in the pre-vaccine era. Contacts aged 15–49 years who lacked written documentation of receipt of 2 or more MCV doses or a history of measles were offered one dose of measles vaccine. Child contacts, 8 months–14 years who had missed routine recommended MCV doses [17] were vaccinated to be up-to-date. Infant contacts aged less than 8 months received no postexposure prophylaxis.

Before the outbreak was declared, all post-exposure vaccination activities were conducted in the nearest immunization clinic. Following declaration, a special immunization clinic was established in each of the 4 buildings. RTs from companies disseminated key messages and prepared lists of eligible contacts. Eligible contacts who missed their vaccination opportunity were urged by RTs to still get vaccinated.

#### 2.2.4. Coordination and social mobilization

RTs organized daily meetings with companies and communities for rapid information exchange and progress reporting. CDC prepared information about measles and its prevention for the public and answered public inquiries by phone and through press conferences, newspaper, TV, radio, blogs, twitter and posters. Technical support for companies was provided by CDC.

### 2.3. Cost and effort

We interviewed each person who had measles after he or she returned to work to obtain data on direct and indirect costs attributable to measles. Direct costs included expenses for physician visits, over-the-counter medications, and transportation to and from hospital clinics. Indirect costs included the number of work-days a case or caregiver missed due to measles illness and costs, if any, for a paid caretaker.

For each involved health care organization, company, and community, we collected descriptions of control activities using semi-structured interviews with RT managers after the outbreak ended. We used field records, including questionnaires, forms, databases, and reports, as memory aids. We surveyed the leader of each control activity to identify the personnel involved, time spent, and the material resources used. The study period was from Jan 10, 2015, when the index case was reported, through Feb 14, 2015, when the outbreak was declared ended.

Hourly or daily earnings were calculated using average salaries in 2015 (234 workdays, 8 h per workday) [18] in each industry categorized by the standard industrial classification system (GB/T 4754–2011) in China [19]. Labor costs were determined by multiplying personnel hours or workdays by the hourly or daily earnings in the corresponding industry. Unit costs included expenses for materials for post-exposure vaccination, laboratory test kits, educational posters, and miles traveled. We used \$0.1 per mile to calculate mileage costs. Overhead costs, fringe benefits, and costs for phone calls were not included. All costs were measured in 2015 RMB and converted to 2015 US dollars based on the average currency conversion rates of 6.5 RMB to 1 US dollar.

## 3. Results

### 3.1. Outbreak setting

The 4 linked office buildings (A, B, C, and D) were in urban areas of Beijing municipality. Each building was equipped with elevators

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