



## The epidemiology of measles in Tianjin, China, 2005–2014



Xiexiu Wang<sup>a</sup>, Matthew L. Boulton<sup>b,\*</sup>, JoLynn P. Montgomery<sup>b</sup>, Bradley Carlson<sup>b</sup>, Ying Zhang<sup>a</sup>, Brenda Gillespie<sup>c</sup>, Abram L. Wagner<sup>b</sup>, Yaxing Ding<sup>a</sup>, Xiaoyan Luo<sup>a</sup>, Tian Hong<sup>a</sup>

<sup>a</sup> Tianjin Centers for Disease Control and Prevention, Tianjin 300011, People's Republic of China

<sup>b</sup> Department of Epidemiology, University of Michigan, Ann Arbor, MI 48109, USA

<sup>c</sup> Department of Biostatistics, University of Michigan, Ann Arbor, MI 48109, USA

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### ABSTRACT

**Background:** Measles incidence in China has declined over the last decade and elimination is targeted by 2020. Despite increases in routine immunization services and supplementary immunization activities (SIAs), periodic outbreaks continue to occur. In this paper, we examine measles epidemiology during 2005–2014 in Tianjin, China.

**Methods:** Measles case data were extracted from a web-based communicable disease surveillance system. We examined the socio-demographic characteristics of measles case patients, including age, sex, urbanicity, residency status, and vaccination history. Demographic characteristics of cases were compared with the general population.

**Results:** From January 1, 2005 to December 31, 2014, 12,466 measles cases in Tianjin were reported. Among the cases, 7179 (57.6%) were male and 5287 (42.4%) were female. Over time, more cases occurred in adults, and for the 2711 cases in 2014, the majority were either infants <1 year (558, 20.58%) or adults ≥20 years (2043, 75.36%). Municipal-wide SIAs in Tianjin occurred in 2008 and 2010 with reduction in measles cases the following year for both (189 cases in 2009, and 37 cases in 2011). The number of cases rebounded to pre-SIA levels or higher within 1–3 years following each SIA: 1990 cases in 2010 and 2711 cases in 2014. Vaccination status was reported as “none” or “unknown” for 84% of all reported measles cases.

**Conclusions:** Despite the general decline in cases, measles outbreaks continue to occur. Although the SIAs reduce numbers in their immediate aftermath, case counts rebound 1–3 years after the intervention. Continued monitoring of cases through disease surveillance activities accompanied by targeted immunization activities, including to adults, can help ensure progress toward elimination.

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### 1. Introduction

In 2005, the World Health Organization (WHO) committed to achieving measles elimination in the Western Pacific Region (WPR) by 2012 [1]. Although that goal was unrealized, China and other countries in the region have nonetheless made impressive progress in measles control, and the WPR is on track to eliminate measles by 2020 [2]. The WPR experienced a greater than 95% reduction in measles between 2000 and 2011 with reported cases falling from 177,052 to 8524, representing a historic low [1] with much of this

improvement attributable to China, home to approximately 75% of the region's population. While China had the overwhelming majority of cases, they also achieved the most dramatic declines from 131,441 in 2008 to 6183 cases in 2012 [2,3].

China's success at controlling measles transmission is attributable to a combination of factors including increased measles vaccination rates and improvements in measles surveillance [4]. China has provided a measles vaccine free of charge through their Expanded Program on Immunization (EPI) starting in 1978 [5], and in 1986, a second measles dose was added to the EPI [6]. Estimated coverage of 2 doses of measles-containing vaccine in children has exceeded 90% since 2006 [2,7], although a 2009 study in Beijing migrant children showed lower coverage (around 88%) [8]. In addition to focusing on routine vaccination and immunization verification prior to school entry, China has carried out a number of large-scale measles supplementary immunization

\* Correspondence to: University of Michigan, Department of Epidemiology, 1415 Washington Heights, 5208 SPH II, Ann Arbor, MI 48109, USA. Tel.: +1 734 936 1623; fax: +1 734 936 2084.

E-mail address: [mboulton@umich.edu](mailto:mboulton@umich.edu) (M.L. Boulton).

activities (SIAs) in an attempt to vaccinate hard-to-reach communities, high-risk counties, and under or unvaccinated children [4]. Approximately 168 million people were vaccinated for measles from 2004 to 2009 in 25 province-wide SIAs [4], and a nation-wide, synchronous SIA vaccinated 102 million children in 2012 [9], with the specific ages targeted in each SIA varying by province. However, despite consistently high coverage, serial SIAs delivering vaccination to millions of children, and historically-low case counts, measles has yet to be eliminated and periodic outbreaks continue to occur [10]. China reported a resurgence in the number of cases to 52,628 in 2014, almost double the number in 2013 and representing a 6-year high [3]. The rebound in measles incidence underscores the importance of sustained control interventions against this highly communicable disease.

The city of Tianjin, one of four province-level municipalities in China, has mirrored measles incidence trends countrywide, and the use of a highly functional immunization information system in combination with ongoing measles surveillance by the Tianjin Centers for Disease Control (CDC) makes them an ideal municipality for characterizing the epidemiology of measles during the elimination phase. Tianjin is located 120 km southeast of Beijing and has a population of approximately 14 million people. Currently, Tianjin uses a 3-dose measles vaccine schedule, with a recommendation for children to be immunized at 8 months, 18–24 months, and again at 4–6 years. Large-scale SIAs were conducted in Tianjin in December 2008 and again in September 2010. The 2008 SIA targeted children aged between 8 months and 15 years and vaccinated 1.2 million children and the 2010 SIA targeted children aged between 8 months and 4 years and vaccinated approximately 450,000 children [11]. Estimates of SIA coverage from official reports are quite high, for example, 96% in Beijing for the 2010 SIA, although some subpopulations may have had lower uptake of the vaccine during these interventions. For example, a survey of migrants in Beijing found only 83.4% of migrant children were vaccinated in the 2010 SIA [12].

Elimination of endemic transmission of measles in China will require a better understanding of who is acquiring measles. Because vaccination is the cornerstone of measles control efforts, detailed information about measles cases is needed in order to evaluate current vaccination programs and inform the development of more targeted vaccination interventions, either through routine immunization services or SIAs. In this paper, we examine the epidemiology of measles over a 10 year period from 2005 to 2014 in Tianjin, China.

## 2. Methods

This study describes measles cases reported to the Tianjin CDC from 2005 to 2014. Measles case data were extracted from the China Information System for Disease Control and Prevention (CISDCP), a web-based communicable disease surveillance system that allows for reporting of communicable disease information from local CDCs, hospitals and other health agencies. Healthcare providers in China are required to report cases of 37 infectious diseases, including measles, to a public health authority under provision of the Law of the People's Republic of China on Prevention and Treatment of Infectious Diseases [13]. China's central public health authority consists of a network of CDCs, headed by the national China CDC in Beijing. Province-level CDCs, including the Tianjin CDC, have jurisdiction over their own area, and approximately 3000 smaller CDCs at the district and local levels report to provincial CDCs. When a diagnosis of measles is made, healthcare providers report case information to their local CDC via the CISDCP web portal. Once case-based information has been entered, all levels of CDC within the appropriate jurisdiction (local, district, provincial, and national) have access to the case information and provide

coordinated investigative follow-up [14]. The WHO-recommended measles case definition, which China adheres to, includes clinical and laboratory criteria for diagnosis, and both were used to define confirmed cases [15].

We examined the socio-demographic characteristics of measles case patients in Tianjin from 2005 to 2014. The CISDCP surveillance report for each measles case consists of basic demographic information (age, sex, occupation, district, and residency status), measles disease summary information, and vaccination history, which includes the number of doses administered for cases in 2009 and later. When presenting results, we divided cases into 3 age categories: infants <1 year of age, children 1 through 19 years of age, and adults  $\geq 20$  years of age wherever appropriate.

The municipality of Tianjin is divided into 16 districts. Among the districts, 7 have been classified as urban (Heping, Hedong, Hexi, Nankai, Hebei, Hongqiao, and Binhai New Area), 4 as suburban (Jinnan, Dongli, Xiqing, and Beichen), and 5 as Rural (Baodi, Wuqing, Ji, Jinghai, and Ninghe). The classifications are based on a district's social, economic, and political structures [16,17]. Within each district, residents may be locals or non-locals. A non-local is someone whose official residency, or *hukou*, is located outside of Tianjin but who is currently residing within the municipality.

Analyses included descriptive statistics such as case counts and proportions. The demographic characteristics of cases were compared to information about the general population from the Tianjin Municipal Statistics Bureau [18]. Statistical tests were not run for these comparisons since the case data and population-level data encompass the entire population, not samples. Data were analyzed using SAS software, version 9.3 (SAS Institute, Inc., Cary NC, USA).

This study was reviewed by the University of Michigan Institutional Review Board and deemed to be exempt from human subject regulation because it was part of standard public health activities.

## 3. Results

From January 1, 2005 to December 31, 2014, 12,466 cases of measles in Tianjin were reported to the CISDCP. Table 1 describes the demographic characteristics of cases. Among cases, 7179 (57.6%) were male, translating to an average rate of 9.1 cases per 100,000 males per year, and 5287 (42.4%) were female—an average rate of 7.7 cases per 100,000 females per year. In general, males were more likely than females to acquire measles, especially among very young children (67% male compared to 33% female in children <1 year of age). Urban districts contain 52% of the population of Tianjin and reported 43% of cases, suburban districts have 19.5% of the population and 25% of cases, while rural districts have 28.2% of the population but 31.9% of cases. The non-local population comprised 26% of measles cases from 2005 to 2014 and constituted approximately 31.8% of the overall population in Tianjin in 2013.

Vaccination status was reported as “none” or “unknown” for 84% of all reported measles cases (Table 2). The proportion of cases with an unknown vaccination status increased by age. For infants, 5.0% had an unknown vaccination status, compared to 33.1% and 69.8% of case-patients aged 1–19 years and 20 years and older, respectively. The vast majority (85.3%) of infant cases had records confirming no receipt of a vaccine, compared to 30.3% of cases aged 1–19 years and 19.7% of adult cases. Few cases in any age group had a documented dose of MCV: 9.8% of infants, 36.7% of cases 1–19 years, and 10.5% of adult cases. Since 2009, when CISDCP first started collecting information on a second MCV dose, 1.5% of cases had 2 doses of MCV, including 14.4% of children 1–19 years, and 0.7% of adults  $\geq 20$  years.

The number of measles cases increased from 1617 in 2005 to 2540 in 2008 (Table 2). Municipal-wide SIAs in Tianjin occurred in 2008 and 2010, and in the year after the SIA, there was a substantial

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