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Original Article

Timeliness and completeness of measles vaccination among children in rural areas of Guangxi, China: A stratified three-stage cluster survey

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ABSTRACT

Background: Large-scale outbreaks of measles occurred in 2013 and 2014 in rural Guangxi, a region in Southwest China with high coverage for measles-containing vaccine (MCV). This study aimed to estimate the timely vaccination coverage, the timely-and-complete vaccination coverage, and the median delay period for MCV among children aged 18–54 months in rural Guangxi.

Methods: Based on quartiles of measles incidence during 2011–2013, a stratified three-stage cluster survey was conducted from June through August 2015. Using weighted estimation and finite population correction, vaccination coverage and 95% confidence intervals (CIs) were calculated. Weighted Kaplan–Meier analyses were used to estimate the median delay periods for the first (MCV1) and second (MCV2) doses of the vaccine.

Results: A total of 1216 children were surveyed. The timely vaccination coverage rate was 58.4% (95% CI, 54.9%–62.0%) for MCV1, and 76.9% (95% CI, 73.6%–80.0%) for MCV2. The timely-and-complete vaccination coverage rate was 47.4% (95% CI, 44.0%–51.0%). The median delay period was 32 (95% CI, 27–38) days for MCV1, and 159 (95% CI, 118–195) days for MCV2.

Conclusions: The timeliness and completeness of measles vaccination was low, and the median delay period was long among children in rural Guangxi. Incorporating the timeliness and completeness into official routine vaccination coverage statistics may help appraise the coverage of vaccination in China.

Introduction

Measles is a highly contagious disease and one of the major causes of death among children worldwide.[1] Vaccination with measles-containing vaccine (MCV) is the most effective way to reduce the morbidity and mortality associated with the disease. Due to worldwide measles vaccination since the 1980s, the reported coverage of measles vaccination across most regions has reached 90% and is as high as 95% in developed countries.[2] However, large-scale outbreaks of measles still occur. In 2010, a total of 33 countries in Europe reported measles outbreaks.[3–7] Most measles cases were aged <12 months or 15–29 years and were either unvaccinated or vaccinated incompletely.[4,6,8] Thus, the goal of measles elimination was not met in WHO Europe Region (WHO/EUR) by 2010.[9] Similarly, outbreaks of measles frequently occur in WHO Western Pacific Region (WHO/WPR), a region with high measles vaccination coverage.[10–13]

China is one of the member nations in WHO/WPR and accounts for 75% of the region's population. Since 2003, approximately 70% of the reported measles cases in WHO/WPR were from China.[14] Thus, the progress towards measles elimination in China is critical for achieving the 2012 measles elimination goal in WHO/WPR.[2,15] Although the reported measles vaccination coverage rate in China has been over 90% since 2006, measles outbreaks still occurred in several provinces, including Guangxi, Beijing, Zhejiang, and Shangdong Provinces.[16–19]

Since 2007, Guangxi has reached 95% coverage for both the first (MCV1) and second (MCV2) dose of measles vaccine, but large-scale measles outbreaks still occurred between 2013 and 2014.[20–22] Of the 1341 and 3167 notifiable measles cases in 2013

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and 2014, 71% and 56%, respectively, were scattered children in rural areas, and 60% and 50%, respectively, were children aged less than 24 months (Data from the Notifiable Infectious Disease Surveillance System in Guangxi Center for Disease Control [CDC]). Among all measles cases, the vaccination coverage rates in 2013 and 2014 were 63% and 51%, respectively; among cases aged 8–12 months, the respective timely vaccination coverage rates for MCV1 were only 23% and 15%. Moreover, high-incidence regions were clustered in West and Southwest Guangxi (i.e., Baise, Chongzuo, Hechi, and Nanning Prefectures). According to WHO recommendation, completeness of measles vaccination means that children should receive the two doses of MCV (i.e., MCV1 and MCV2) so as to prevent outbreaks of measles.[23] Thus, the measles outbreaks may reflect a lack of herd immunity against measles among children in rural Guangxi, which implies that complete measles vaccination might not be routinely delivered to susceptible populations on time.

In theory, high reported measles vaccination coverage (>95%) should protect children against measles.[24] It is worth noting that the timeliness of vaccination is not usually reported in the official vaccine coverage statistics.[25] Reported coverage may mask substantial delays in vaccination and neglect the timeliness of vaccination.[26] Therefore, timely vaccination may be a key to achieving elimination of measles. Here, we hypothesized that the timeliness of measles vaccination may be poor in measles-endemic areas of Guangxi.

Previous studies have revealed that untimely vaccination of measles poses a threat to susceptible children.[27–35] However, most studies focused on urban children, and rural children were neglected. Few studies have assessed the timely vaccination for MCV2 or the median delay period, and no study has explored the timely-and-complete vaccination for MCV1 and MCV2. Furthermore, few studies have used complex sampling designs and weighted analysis methods to determine the measles vaccination coverage at the national or provincial level. Additionally, there is a paucity of studies on the timeliness and completeness of measles vaccination in China, particularly in western rural areas.

Therefore, a stratified three-stage cluster survey was conducted among children aged 18–54 months in rural Guangxi, with the aim of determining the timely vaccination coverage rate of MCV, the timely-and-complete vaccination coverage rate of MCV, and the median delay period of MCV using weighted estimators appropriate to the complex survey design. Results of this study may help provide a better understanding of the possible explanations for the large-scale outbreaks of measles in rural Guangxi, a region with high measles vaccination coverage.

Methods

Study design and setting

The present study was a cross-sectional multi-stage cluster survey, and the study setting was rural areas of Guangxi Zhuang Autonomous Region. Zhuang, the largest minority ethnicity of China, are mainly distributed in Guangxi, a typically mountainous area in Southwest China (Fig. 1). Guangxi is one of the five autonomous regions in China, where Zhuang, Han, Yao, and Miao ethnicities are the major residents. Guangxi consists of 14 prefectures and 109 counties, with an area of 236,700 km^2 and a population of 46.8 million residents in 2012. Geographically, Guangxi has proximity to the Association of Southeast Asian Nations (ASEAN) member states. In this study, rural areas were defined as any county or county-level city. A total of 75 counties or county-level cities were classified into rural Guangxi.

Study population

According to the national Expanded Programme on Immunization (EPI) in China, routine measles vaccination comprises two doses of MCV. Children should be vaccinated with MCV1 at the age of 8 months, and MCV2 should be given to children between the ages of 18 and 24 months.[26] To determine the timeliness of measles vaccination among a child cohort having approximately the same age distribution as the measles cases, the population of interest was defined as children aged 18–54 months in rural Guangxi. Ideally, children in this age range should have received at least one dose of MCV.

The inclusion criteria for target children were: (1) living in rural Guangxi for at least 3 months, (2) age 18–54 months at the time of interview, (3) availability of child's vaccination certificate, and (4) the primary guardian of the child able to communicate verbally in local language or Mandarin Chinese without any barriers. We recruited investigators who could speak the local language fluently, and employed local vaccination practitioners to interview the primary guardian. Children were excluded if they had any contraindications for vaccination or if they received any dose of MCV outside of their hometown.

Sample size

A total of at least 1200 children were required to estimate the timeliness of MCV with a precision of 4% and type I error rate of 5%. Given the reduction of sample efficiency and estimation precision under the cluster sampling design, a design effect of 2.0 was used.[36] No previous information on the coverage of timely-and-complete MCV could be found, so we used an estimated 50% coverage.

WHO recommends that it is feasible to sample 30 clusters (villages) from each county.[37] Thus, four counties with a total of 120 clusters were selected. In each county, 30 clusters and 10 children per cluster were sampled.

Sampling technique and sampling procedure

The present study was a stratified three-stage cluster survey. In stratified sampling, all 75 rural counties were classified into four strata based on quartiles of measles incidence during 2011–2013. There were 17 counties in the first stratum, 12 counties in the second stratum, 21 counties in the third stratum, and 25 counties in the fourth stratum. From the first (lowest incidence) to fourth stratum (highest incidence), one county per stratum was randomly selected: Longan, Zhaoping, Wuxuan, and Longlin Counties. At the first stage of cluster sampling, five towns per county were randomly selected. At the second stage, six villages per town were randomly selected. At the third stage, ten children per village were randomly selected from a list obtained from the local township hospitals, which contains the number and names of all the children in the target age range in the area. If two or more eligible children were in the same household, only the youngest child was selected.

Data collection and data management

The survey was conducted from June through August 2015. Data on vaccination date for MCV1 and MCV2 and the child's date of birth were extracted from the child's vaccination certificate, which is a booklet containing information on all routine vaccinations received. The lists of target children for each sampled village were collected from the local township hospitals. Incidence of measles for each county was gathered from Guangxi CDC. Other information, such as population sizes and lists of counties, towns, and villages, were obtained from Guangxi Bureau of Statistics.

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