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Sociodemographic and economic characteristics of susceptibility to rubella among women preparing for pregnancy in rural China

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ABSTRACT

Objectives: Infection with rubella virus during pregnancy can result in congenital defects and adverse pregnancy outcomes. The risk of rubella infection is greatly determined by the level of rubella antibodies in the serum. A survey of rubella antibody seronegativity rates was conducted in 780 000 women in rural China who were planning a pregnancy, in order to evaluate the herd susceptibility in different age groups and by high, middle, and low GDP per capita regions.

Methods: In order to evaluate the herd susceptibility to rubella, a nationwide population-based study of rural Chinese women who were planning to have a baby and who were aged 21–49 years was instigated. As a part of the National Free Pre-conception Health Examination Project covering 29 provinces in 2012, a physical check-up program was provided to women who planned to become pregnant within the next 6 months. All medical data were from serological samples tested by ELISA, and the participants' immunity status was categorized based on levels of rubella antibodies. Economic data were also collected to explore the association between herd susceptibility and socioeconomic characteristics in the women of childbearing age.

Results: A total 264 306 of 782 293 recruited women preparing for pregnancy tested susceptible to rubella (33.79%). The seronegativity rate in women with a history of vaccination was significantly lower than that in women who had not received the vaccination or did not know their vaccination history (23.76%, 33.70%, and 35.68%, respectively). The seronegativity rates were 26.89%, 37.86%, and 32.61% in high, middle, and low GDP per capita areas, respectively. After stratified analysis and adjusting for other factors by multiple logistic regression, the lower seronegativity rates in women in high GDP per capita regions compared to women in middle and low GDP per capita regions remained in the different age groups and subgroups of immunization history.

Conclusions: There is a clear difference in rubella-specific susceptibility among rural women preparing for pregnancy of different sociodemographic and economic backgrounds. The number of rubella-susceptible rural women preparing for pregnancy, especially in relatively low GDP per capita regions in China, was high. Offering rubella vaccination to women who are rubella-susceptible and who plan to become pregnant should become one of the priorities in the field of public health work in China.

Introduction

Rubella remains an important pathogen worldwide, with roughly 100 000 cases of congenital rubella syndrome estimated to occur every year (Lambert et al., 2015). Infection with the rubella virus contracted during pregnancy can be vertically transmitted to the fetus, resulting in miscarriage, stillbirth, or congenital rubella syndrome (CRS), the latter comprising a pattern of fetal anomalies that includes cataracts, hearing impairment, cardiac disease, and developmental delay (Lambert et al., 2015; Cozza et al., 2015; Reef et al., 2002). If CRS occurs in the first trimester of pregnancy, the proportion of infants with congenital defects can be up to 90% (Banatvala and Brown, 2004).

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China is the most populous country in the world and is also a country with a high incidence of congenital defects. According to the congenital defect monitoring network based on hospital data, the total incidence of congenital defects in China is between 1% and 3% (Dai et al., 2011; Zhang et al., 2012; Fan et al., 2013; Xie et al., 2016), and this is a significant cause of neonatal mortality (Feng et al., 2011; Wang et al., 2016; He et al., 2017). Therefore, preventing congenital defects has become one of the important health goals of the Chinese government.

The levels of rubella antibody (IgG) in women of childbearing age are the determinants of whether rubella infection occurs or not during pregnancy. IgG negativity indicates the individual's susceptibility to rubella virus. At the global level, a recent meta-analysis showed that a high proportion of women of childbearing age are still susceptible to rubella (Pandolfi et al., 2017). According to reports from European countries where there are routine immunization programs for rubella, seronegativity rates in women aged 15–39 years range from 1.4% to 13.4% (Lao et al., 2015).

A single-dose rubella vaccine was introduced in China in 1995. At that time, vaccine recipients had to pay for the vaccine themselves (Lin et al., 2015; Gao and Hethcote, 2006). The rubella vaccine was included in the national expanded program on immunization in China in 2006, focusing on children, and these recipients were vaccinated for free (Chen et al., 2013). Since then, several small-sample susceptibility studies have been performed among the resident population and among female migrant factory workers in Beijing and Shenzhen in China (Lao et al., 2010; Mou et al., 2010). However, data from nationwide large-sample rubella-specific susceptibility studies in women who are planning to have a baby are limited.

A population-based survey of rubella seronegativity rates was conducted in 780 000 women who were planning to have a baby in order to evaluate the sociodemographic and economic characteristics of susceptibility to rubella in rural China. Furthermore, it was sought to provide some evidence-based suggestions on reducing the risk of rubella virus infection in woman during pregnancy to help prevent and control congenital defects in China.

Methods

Study design and participants

This was a nationwide, population-based, cross-sectional study. Data used were obtained from a physical check-up program aimed at couples of reproductive age as part of the national Free Pre-conception Health Examination Project (NFPHEP) in China. Data were obtained from the NFPHEP database. This project was launched by the Chinese National Health and Family Planning Commission and Ministry of Finance in 2010 and offers free pre-conception health examinations for married couples living in rural areas who are planning a pregnancy within the next 6 months.

In this study, all women in the couples agreed to a medical examination, together with pre-conception counseling advice. Trained local health workers built a standardized health file for every participant. This file included data from a questionnaire survey and the medical examination. Files were then sent to the national office by Web-based electronic data collection system. Details of the design, organization, and implementation of this project have been described elsewhere (Liu et al., 2016; Zhang et al., 2015; Wang et al., 2015). From January 1, 2012 to December 31, 2012, a total 810 537 women aged 21–49 years were enrolled from 199 counties by the NFPHEP using a two-stage stratified cluster sampling method that covered 86% of the target population. Serum samples from 782 293 of the 810 537 women (96.52%) were tested and the data were included in the final analysis.

Written informed consent was obtained from each participant before enrollment. The study was approved by the Institutional Review Board of the Chinese Association of Maternal and Child Health Studies.

Procedures

A standardized questionnaire was used to collect basic participant information, including age, education level, residential address, and immunization history. Personal immunization history records were not available, hence information related to rubella immunization history was based on participant recall. According to their residential addresses, the participants came from 29 provinces in five regions: South China (including Guangxi, Guangdong, and Hainan), North China (including Beijing, Tianjin, Hebei, Shanxi, Inner Mongolia, Liaoning, Jilin, and Heilongjiang), Southwest China (including Chongqing, Sichuan, and Tibet), Northwest China (including Shaanxi, Gansu, Qinghai, Ningxia, and Xinjiang), East China (including Fujian, Jiangsu, Anhui, Shandong, Shanghai, and Zhejiang), and Central China (including Henan, Hunan, Hubei, and Jiangxi).

The regional gross domestic product (GDP) per capita was used to evaluate the level of economic development of the 29 provinces in China. GDP per capita is the indicator of a regions' economic development. It is calculated per region in a year to achieve the GDP divided by the population of the region (Zaganjor et al., 2016). All of the GDP per capita data for all provinces were obtained from the China Economic Information Network (http://www.cei.gov.cn/). The 29 provinces were divided into three levels of GDP per capita regions using the following rule: high GDP per capita region = over $8000; middle GDP per capita region = between $5000 and $8000; and low GDP per capita region = below $5000 (Figure 1). The target population was women aged 21–49 years from rural China.

Venous blood (5 ml) was collected from each participant and sent to local laboratories where the serum was separated and stored at −30 °C before being tested. All serum specimens were tested in local laboratories affiliated to medical institutions under qualified quality control mechanisms. Rubella antibody levels were detected using available ELISA kits. The kits selected to test rubella antibodies in the serum samples and used by the laboratories of the local medical institutions in the counties were approved by the State Food and Drug Administration of China and were used in accordance with the standards required by the NFPHEP. In accordance with the quality control standards of the NFPHEP, local laboratories in the medical institutions at county level were responsible for quality control of rubella virus antibody test results. All kits were tested by the National Center of Clinical Laboratories for Quality Inspection and Detection. The sensitivity, specificity, and k-value of the selected reagents from all of the counties involved were higher than 95%. The National Center of Clinical Laboratories for Quality Inspection and Detection performed sampling twice a year to test the results of the local laboratories in the 199 counties, in order to evaluate and ensure the consistency of results.

In this study, participants who tested negative for anti-rubella IgG were considered to be susceptible to rubella.

Statistical analysis

Proportions were calculated to describe the sociodemographic characteristics of the participants. The seronegativity rate for rubella was calculated with the 95% confidence interval (95% CI) for the entire study group and for the different sociodemographic and economic characteristics. Based on GDP per capita levels, the seronegativity rates for rubella were calculated for the different age groups and subgroups of immunization history. Logistic