Vaccine xxx (2015) xxx–xxx

Contents lists available at ScienceDirect

Vaccine

journal homepage: www.elsevier.com/locate/vaccine

Factors associated with non-vaccination against measles in northeastern Brazil: Clues about causes of the 2015 outbreak

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ARTICLE INFO

Article history:
Received 21 April 2015
Received in revised form 8 July 2015
Accepted 9 July 2015
Available online xxx

Keywords:
Measles
Mass vaccination
Disease outbreaks
Child
Preschool

ABSTRACT

Measles is a highly contagious disease that can be effectively prevented through vaccination. The recent increase in vaccination coverage was successful in reducing the mortality globally of the disease by 74%. As a whole, the Americas have been considered a disease-free zone. However, it is known that if an immunization programs fails, there will be an accumulation of susceptible people that can lead to disease outbreaks. Recently, both the United States and Brazil faced outbreaks of measles. The present study aims to identify the determining factors of non-vaccination in Brazil in two different vaccination coverage moments, to provide clues as to the causes of current outbreaks. Data were drawn from five population-based cross-sectional studies that surveyed a representative sample of preschool children from 1987 to 2007 (9585 children in total). To assess children's vaccination status, two different information sources were used: information provided by mothers and information from children's health cards. Multivariate analyses with logistic binary regression models were conducted. After adjustment for confounding factors, it was observed that in 1987, with 48.2% vaccination coverage, socioeconomic, maternal, nutritional factors and access to health facilities were important, while in 2007 (96.7% coverage), nutritional and maternal factors were important. Distinct patterns of determinants of non-vaccination were also found. In addition, the low coverage in 1987 resulted in a current pool of adults who were not immunized as children; this may have contributed to the beginning of the current Brazilian outbreak. Globally, there are two standards of vaccination coverage (low and high). Therefore, discussion of the determinants of non-vaccination is important. Our findings suggest vulnerable groups should receive special attention to ensure they are protected. It is also important to consider the possible impact of pools of adults not immunized.

1. Introduction

Measles is a highly contagious disease caused by a virus and transmitted through the air, and mainly affects children. There is no specific treatment and most people recover after 3 weeks. However, particularly in malnourished children and people with reduced immunity, measles can cause severe neurological sequelae [1]. Measles can be effectively prevented through vaccination, and the recent increase in vaccination coverage globally successfully reduced the mortality of the disease by 74%, accounting for about a quarter of overall child mortality from 1990 to 2008 [2,3].

In 2010, the World Health Organization (WHO) defined three main objectives for the eradication of measles by 2020: 90% vaccination coverage in children under 1 year of age; reducing and maintaining the annual incidence of measles to less than five cases per million; and reducing measles mortality by 95% in 2015 compared with 2000 [4].

As a whole, the Americas, consisting of 35 member states, have been considered a disease-free zone since 2002; the first region in the world to achieve this WHO goal. These countries prioritized the control of measles vaccination to reach the goal of eradication [5].

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http://dx.doi.org/10.1016/j.vaccine.2015.07.027
0264-410X/

Despite this success, and that five out of six WHO regions have set goals for the elimination of measles [6], if immunization programs fail to achieve coverage for the newly susceptible, there will be an accumulation of non-vaccinated people that can lead to disease outbreaks [6,7]. This may have been what happened in the United States, where measles was eradicated in 2000, but where, between January 1 and March 20, 2015, outbreaks were experienced in 17 States (178 confirmed cases) with these cases assigned to visitors and/or non-vaccinated Americans [7,8]. In June of 2015, the United States registered one death by measles after 12 years without fatal cases. There have also been recent measles outbreaks in Canada [4].

In Brazil, measles has been considered under control since 2002 [8]. The goal of elimination of measles in the region of the Americas by the year 2000 was set at the 24th Pan American Sanitary Conference in 1994, with approval by resolution of the Ministers of Health present or represented at the event. Brazil's national information system began to collect information on vaccination coverage from this time [9]. Earlier, in 1992, the first national mass campaign of measles vaccination was carried out, achieving by this time an estimated coverage of 96%, which trigged the trend of decline of the disease in the country. Indeed, the incidence of measles has fallen sharply from 97.7 per 100,000 inhabitants in 1996 to no cases detected in the years of 2004 to 2009, with a vaccine coverage almost universal: 98.3% in 2011. The last autochthonous case of measles had been registered in the country in 2000, with some localized imported cases been eventually detected [9]. However, a recent measles outbreak occurred in the state of Ceará, in northeast Brazil, which has the largest population in the world living in a semi-arid climate. Up to March 18, 2015, Ceará had 788 confirmed measles cases; approximately eighty cases per million inhabitants. A substantial proportion of 30.2% of these patients were adults, aged 20 to 29 years [10]. These patients were identified by the SINAN, the national contagious diseases surveillance system, which establishes that all suspect cases of measles must be notified to the governmental health authorities by health workers and that all positive immunologic tests for measles done in Brazil must also be notified. Weekly bulletins about the numbers of cases are routinely released in Ceará. The Brazilian government had no systemized information on vaccination coverage before 1994, when those people, now aged 20–29 years, should have been vaccinated as children [9]. Ceará concentrates 36% of Brazilian cases of exanthematic diseases [11]. With more than 200 million inhabitants, Brazil must prioritize the prevention of accumulation of susceptible people.

Globally, there are few population studies on the determinants of measles vaccination. Most of the available studies involved small groups or used secondary data, were conducted in areas with low vaccination coverage, and found that low coverage was mostly related to inequity [12–14]. Therefore, the present study aims to describe the vaccination coverage and identify the determining factors of non-vaccination for measles in Ceará in two different health and socioeconomic moments, one with high coverage, measured by state-wide household surveys. Knowing the determinant factors of non-vaccination can help health managers to plan adequate interventions in order to obtain ideal vaccination coverage. It can also be important to identify the situations that favor the outbreak, despite the high vaccination for measles to the children, at this moment.

2. Methods

Five population-based cross-sectional studies on maternal and child health (PESMICs) surveyed a representative sample of preschool children up to 36 months of age, living in Ceará, in northeastern Brazil. The surveys were carried out in 1987, 1990, 1994, 2001 and 2007, using the same methods each time. For the present study, data from the 1987 and 2007 surveys were used.

Ceará is one of the poorest states in the country, with a population of 8.2 million people living in a semiarid climate. Social security benefits and cash transfer programs (e.g., *Bolsa Familia* program) provided to families have become a main source of income for Ceará's rural population.

The surveys used cluster sampling, based on the Brazilian Institute of Geography and Statistics (IBGE) census tracts and stratification between the state capital Fortaleza, and the rural area. Census tracts result from the division of each municipality into geographic areas with variable extensions, but with a uniform population of 300 families. The sample size was calculated as 8000 households, representing about 35,000 people: 11,000 women aged 10–49 years old and 2000 children under 3 years of age. The initial sample size was multiplied by a correction factor equal to 2, covering the design effect of cluster sampling. In addition, the sample was increased by 10% to compensate for losses.

To ensure the study population was representative, selection of municipalities, census tracts and households was random. Once a census tract was defined and its corresponding map obtained, the location of the cluster of 20 houses to be investigated was defined. The starting point of the cluster (the first home to be visited) was randomly selected. Households were visited consecutively, in a counterclockwise direction. Shops and uninhabited buildings were excluded and replaced; and in the case of absent families, up to three return visits were conducted in an attempt to obtain data. In each household, information was obtained about all children through their mother or main caregiver and the children's anthropometric measurements were taken.

To assess children's vaccine status, two different information sources were used: information provided by the mother/caregiver and information from the child's health card. The two information sources were compared when analyzing the data to validate the information, and only used if there were no contradictions. The Kappa test was applied to assess the concordance between the two sources in 1987 and 2007, resulting in indexes of 0.93 and 0.97, respectively.

Measles vaccination program changed along the time in Brazil. In 1987, children who had the monovalent measles vaccine by 12 months of age were considered to be covered by the vaccine, as the recommended vaccination date was up to 9 months. In 2005, was introduced in Brazil the "viral triple" vaccine in substitution to the monovalent measles vaccine [15]. Governmental policy was to vaccinate children with the viral triple by 12 months of age. By the time of the 2007 survey, both kinds of vaccine had been in use. As the children studied had up to three years, children who had received the single measles vaccine by 12 months of age or the "viral triple" vaccine (for measles, mumps and rubella) by 15 months were considered to be immunized.

In addition, the following data were collected on children and their families: socioeconomic and demographic characteristics (family income, availability of water, availability of toilets); child care (breastfeeding, father living with the family, mother's education); health care (child possessed a health card, medical consultations, immunization); biological characteristics (age, sex, birth weight); and history of morbidity (hospitalization for diarrhea, hospitalization for pneumonia).

Information used in the present study was collected from August to November in 1987, and from July to December in 2007, using three questionnaires covering household, maternal and child factors. The questionnaires were reviewed daily by field supervisors to identify and correct errors whenever possible. During the fieldwork, data of a subsample (10% of children) were reassessed by supervisors for quality control. Full details on the study methods can be found elsewhere [16].

Data were entered twice using EpiInfo 2000 and analyzed using SPSS Version 17 (SPSS Statistics for Windows, Version 17.0.

Please cite this article in press as: Rocha HAL, et al. Factors associated with non-vaccination against measles in northeastern Brazil: Clues about causes of the 2015 outbreak. Vaccine (2015), http://dx.doi.org/10.1016/j.vaccine.2015.07.027