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Measles epidemic in Brazil in the post-elimination period: Coordinated response and containment strategies

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ABSTRACT

The measles virus circulation was halted in Brazil in 2001 and the country has a routine vaccination coverage against measles, mumps and rubella higher than 95%. In Ceará, the last confirmed case was in 1999. This article describes the strategies adopted and the effectiveness of surveillance and control measures implemented during a measles epidemic in the post-elimination period. The epidemic started in December 2013 and lasted 20 months, reaching 38 cities and 1,052 confirmed cases. The D8 genotype was identified. More than 50,000 samples were tested for measles and 86.4% of the confirmed cases had a laboratory diagnosis. The beginning of an campaign vaccination was delayed in part by the availability of vaccine. The classic control measures were not enough to control the epidemic. The creation of a committee of experts, the agreement signed between managers of the three spheres of government, the conducting of an institutional active search of suspected cases, vaccination door to door at alternative times, the use of micro planning, a broad advertising campaign at local media and technical operative support contributed to containing the epidemic. It is important to recognize the possibility of epidemics at this stage of post-elimination and prepare a sensitive surveillance system for timely response.

1. Introduction

Measles is a highly contagious infectious disease; its major complications include pneumonia, encephalitis, and death [1,2]. The global strategy for eliminating measles is based on the fact that it is only transmitted between humans, the existence of an effective vaccine that provides protection for a long time, and the cost-effectiveness of immunization activities [3,4]. The benefits of the vaccine are undeniable, and the morbidity and mortality statistics clearly reflect the impact of the introduction of vaccines and high vaccination coverage in specific populations [5]. Despite the existence of a vaccine, measles remains a major cause of morbidity and mortality among children under five years, especially children who are malnourished and those living in countries with weaker economic development [6].

The endemic transmission of the measles virus from other parts of the world remains a risk for regions that have eliminated the disease, and unless there is an interruption of the virus's transmission worldwide, there is the possibility of imported cases and outbreaks. Although measles was declared eliminated in the Americas in 2002 [7,9], sporadic introductions end up in transmission chains [10–15], which are extended depending on the routine vaccination coverage of the resident population [16]. Thus, the main challenges for maintaining measles elimination are sensitive surveillance, an effective response to the import of wild virus, homogeneous and routine vaccination coverage (>95%) in cities and integrated action plans that involve intersectoral activities, including the private sector [17–25].

In northeastern Brazil, there was a measles epidemic between 2013 and 2015 that lasted 20 months and affected 1052 people

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in 38 cities in the State of Ceará after 13 years without an endemic outbreak [10].

This article describes the strategies adopted and the effectiveness of the surveillance and control measures implemented during the epidemic in an attempt to understand the challenges posed by the regional context of post-measles elimination and explain the actions taken to prevent the re-establishment of endemic transmission when the virus is imported.

2. Methods

A descriptive study was conducted to examine immunization strategies, epidemiological and laboratory surveillance, and communication to contain and halt the chains of measles transmission during an epidemic between December 2013 and October 2015.

2.1. Data source

Data were collected from the Compulsory Notification Disease Information System (SINAN) of the Ministry of Health of Brazil, to which suspected cases of measles are reported. Additionally, the laboratory results were analysed through the Laboratory Environmental Management System (LAG) of the Central Laboratory of Public Health of Ceará (LACEN). Vaccination data were collected through the National Information System of the Immunization Programme (SIPNI), which aggregates data regarding routine vaccination coverage or vaccination campaigns. Data were also collected from field research reports, minutes of meetings that occurred during the epidemic, and the final report by the State Department of Health of Ceará on the closure of the epidemic.

2.2. Periods analysed

To analyse the actions taken to fight the measles epidemic in Ceará, the epidemic was divided into four stages (Fig. 1).

1st period: the introduction of the measles virus and its spread to cities in the metropolitan region of Fortaleza (Epidemiological week (EW) 52/13 to 10/14 – December 25, 2013, to March 8, 2014);

2nd period: interiorization of the virus and its spread to the countryside cities of the state (EW 11 to 42/14 – March 9 to November 18, 2014);

3rd period: maintenance of virus transmission in the cities of Fortaleza and Caucaia (EW 43 to 53/14 – November 19, 2014, to December 31, 2014;

4th period: transmission control and evidence of interruption of the virus's circulation (EW 01 to 27/15 – January 1, 2015, to July 6, 2015; Fig. 1).

2.3. Operational definitions of immunization measures

The calculation of routine vaccination coverage (RVC) was based on the number of applied MMR doses (measles, mumps and rubella [MMR]) by age group and city of residence divided by the total population of the vaccine's target age group during the same period, expressed as a percentage. The data used are public and are available at DATASUS (PNI and demographic data) [18].

The **contact vaccine** was administered with the MMR vaccine or the double virus vaccine (measles and rubella [MR]) in contacts over the age of six months within 72 h of contact. This measure included those with contact with the places where suspected cases were located during the disease's period of communicability.

As part of the rapid monitoring of routine vaccination coverage (MRC), city health teams used maps of census sectors, list of localities produced by endemic disease control agents, territorial areas of primary care, neighbourhood divisions/blocks from the city administrative regions, among other factors, to identify, enumerate and select the sectors in which interviews would be performed. The participating households in each sector were selected through convenience sampling. The number of people interviewed in each RCM was obtained by dividing the target population by the number of vaccine clinics in the city, as follows: when the result was <1000, ≥1000 and <5000, ≥5000 and <10,000 and ≥10,000, the numbers of people interviewed in the target population were 25, 50, 75 and 100, respectively [18].

The scanning vaccination, also called the cleaning operation, is an activity in which the vaccination status of all individuals aged 6 months to 49 years is checked by going door to do and vaccinating people selectively according to their vaccination his-

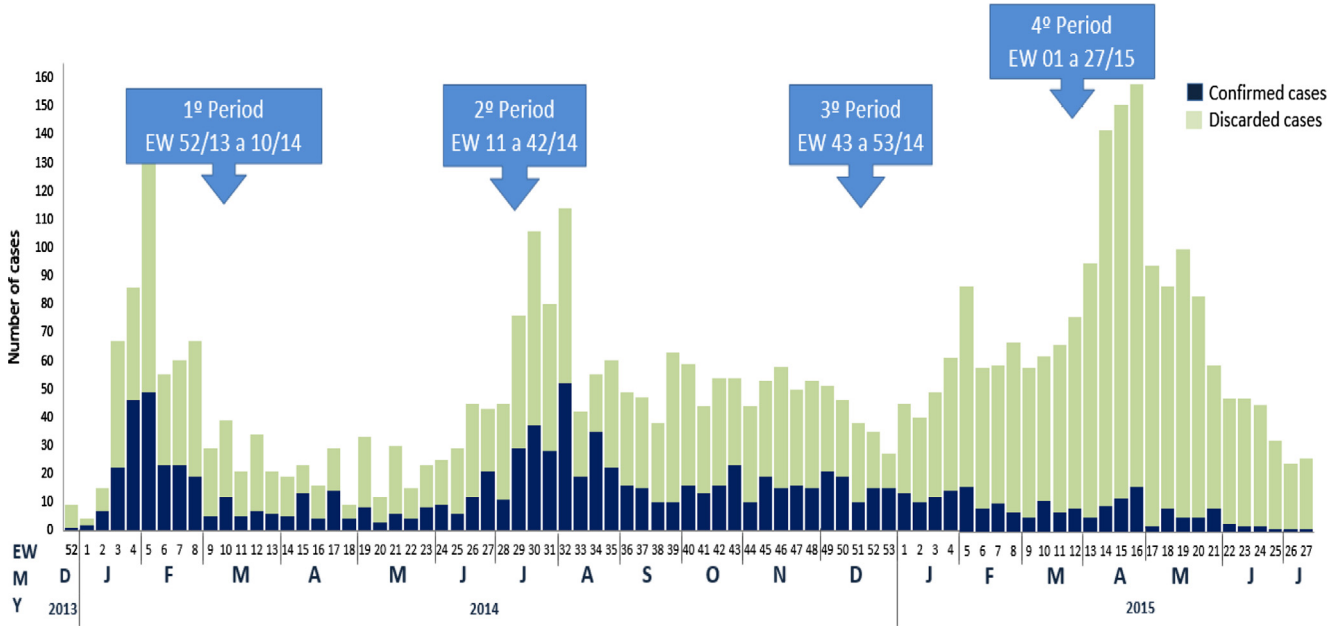

Fig. 1. Period of measles epidemic in Ceará, 2013–2015.

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tory. This procedure is performed when cases of the disease are still occurring after the implementation of other vaccination actions.

The Ministry of Health of Brazil periodically provides vaccinations in **follow-up campaigns** that aim to vaccinate unvaccinated children or those with an incomplete vaccination scheme, especially those in preschool. This strategy is recommended when the number of unprotected children in a certain age group accumulates, either because they have not been vaccinated or because of primary vaccine failure. In follow-up campaigns, the vaccine is administered indiscriminately.

Vaccine intensification involves providing vaccination outside of health facilities to eliminate susceptible pockets and to ensure that all areas have routine vaccine coverage for the maintenance of herd immunity. It consists of providing vaccinations in areas with high concentrations and flows people by searching for unvaccinated individuals aged 5–29 years, especially those living in rural and difficult-to-access urban areas. The goal is to evaluate the immunization status of each individual in this age group and vaccinate where appropriate.

2.4. Operational definitions of epidemiological surveillance actions

In the post-elimination stage, a single confirmed case of measles represents an epidemic because it exceeds the expected number of cases.

A **suspected case of measles** occurs when a person of any age presents fever and maculopapular rash accompanied by a cough and/or a runny nose and/or conjunctivitis [19]. In the **investigation** of suspected cases, we used a structured questionnaire with information about travel in the 21 days before the onset of the rash. From the information collected, **timelines** were created, considering periods of exposure, incubation, transmissibility and follow-up with contacts (Fig. 2). From there, vaccine blocking actions were commenced, including an **active search** for contacts in places in the community where the case had been (using pictures of measles cases) based on medical sheets and records from the last 30 days. **Contacts** of suspected cases were defined as people living in the home or other shared, enclosed spaces during the period of communicability. These contacts were monitored for up to 30 days for the early detection of possible symptoms of measles.

A **confirmed case** of measles was determined for every patient, regardless of age and vaccination status, who presented fever and maculopapular rash accompanied by one or more of the following signs and symptoms: cough and / or coryza and / or conjunctivitis and laboratory diagnosis OR a patient with the same symptoms and who had contact with a case confirmed by laboratory criteria [19,20].

2.5. Operational definitions of laboratory surveillance

Research findings have recommended the collection of a blood sample during the acute phase of the disease to research IgM and IgG specific to measles, rubella and dengue IgM using enzyme-linked immunosorbent assay (ELISA), and a second collection was recommended ten days later if the first showed a positive IgM for measles [20]. In such cases, a nasopharyngeal swab or urine sample was also collected to search for the virus using RT-PCR.

At the end of the analysis, the cases were classified as confirmed if seroconverted IgM and/or IgG the virus itself was identified in the processed samples. Cases were also confirmed cases through an epidemiological link with laboratory-confirmed cases.

All the samples were processed in the Ceará Central Laboratory of Public Health (LACEN). For quality control, the positive samples were sent to the reference laboratory for Measles and Respiratory Viruses of the Oswaldo Cruz Foundation (Fiocruz).

2.6. Ethical aspects

The study was authorized by the Ministry of Health and respected all ethical precepts of Resolution 466/2012. It was approved by the Research Ethics Committee with the CAAE - 43405315.3.0000.5049.

3. Results

3.1. Scene of occurrence and factors behind the spread of the virus

Between December 2013 and October 2015, the epidemiological surveillance system received notification of 4631 suspected cases of measles, of which 1052 were confirmed. The virus was present in 38 (20.7%) of the 184 cities in Ceará, and transmission lasted 20 months.

The conditions in the state at the time of the virus's introduction can explain the magnitude and duration of the epidemic. The highly contagious nature of the virus; the feeling of security resulting from high routine vaccination coverage at that time; the existence of a susceptible population distributed throughout the territory; the surveillance system's weak ability to detect suspected cases, research them and initiate a timely vaccination blockade; and the perception that there would be a prompt and adequate response to the introduction of the measles virus were instrumental to its rapid spread. Added to this scenario is the political transition resulting from a change in city administrations, which made it difficult to meet commitments to and implement the financial resources for vaccine-preventable disease surveillance activities. Concomitantly, the occurrence of large public events, 2013 FIFA Confederations Cup Brazil and 2014 FIFA World Cup Brazil, led to a heavy flow of tourists, including those from areas with an indigenous transmission of measles. The first affected cities experienced a substantial flow of tourists, and resident population shifts also contributed greatly to the rapid spread of the virus.

The first official statement on the measles epidemic occurred with the arrival of new technical and policy makers in January 2015, more than a year after the introduction of the virus.

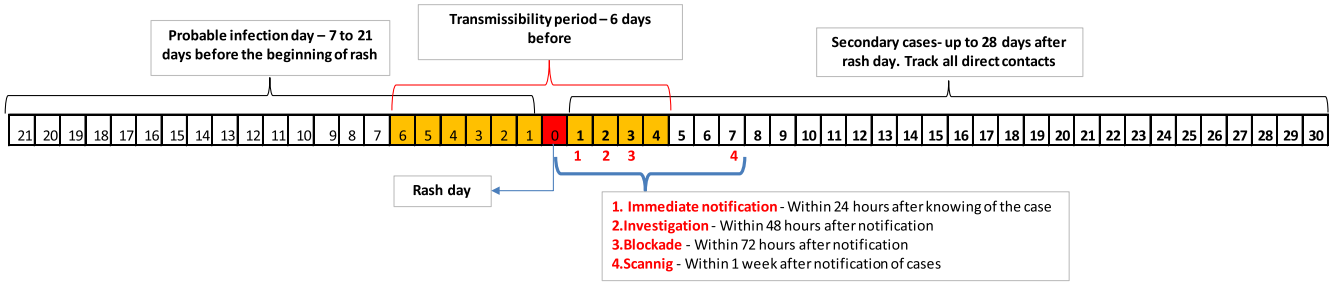

Fig. 2. "Timeline".

Weaknesses were identified in the work process of the health teams, especially in terms of providing primary care and identifying and enacting timely actions for suspected cases. Another limiting aspect was the health teams' lack of access to the most remote communities because of risks linked to violence.

The wide circulation of dengue cases in the region, coupled with the long period without the occurrence of measles cases, corroborated to decrease the sensitivity of health professionals, resulting in a late diagnosis of measles. And that late diagnosis resulted in patients repeatedly visiting health centres in search of assistance during the period of greatest transmissibility of the disease.

3.2. 1st period: the introduction of the measles virus and spread to cities in the metropolitan region of Fortaleza (EW 52/13 to 10/14 - December 25, 2013, to March 8, 2014)

By the end of January 2014, the virus had spread to 10 cities in the state's metropolitan region (Fortaleza, Caucaia, Barreira, Itaitinga, Jaguaribe, Maracanaú, Maranguape, Massapê, Trairi and Uruburetama), demonstrating its great potential for transmissibility.

The resident population in Ceará is approximately 8.5 million inhabitants, and more than three million doses of vaccines with the measles component were administered throughout the epidemic using different vaccination strategies.

3.2.1. Index case identification and spread of the virus

On January 11, 2014, the epidemiological shift of the Ceará Health Secretary received notification of a suspected case of measles. It was the index case of the epidemic: a 27-year-old male doctor living in the city of Fortaleza with no history of vaccination and presenting with a fever, rash, conjunctivitis and cough for seven days. In the interview, the patient denied contact with people who had a rash but reported having participated in an event at the end of 2013 where foreign tourists were present. During the transmissibility period, the patient was on duty at three different hospitals in Fortaleza. Exams performed on January 12 showed an IgM positive result for measles, which was later identified as the D8 genotype in a molecular biology examination. In January 2014, after confirmation of the index case, records and attendance sheets were retrospectively searched for suggestive symptoms of measles, which identified the primary case. In addition, the Ceará Central Laboratory of Public Health (LACEN) tested all samples of suspected dengue patients with early symptoms in December 2013, and no samples were positive for measles.

Approximately 2000 health professionals were trained on how to contain the measles epidemic. Throughout the whole year of 2014, the main communication strategy for the epidemic involved interviews on local TV news and the release of weekly epidemiological bulletins produced by the Health Board.

The Health Board of the State of Ceará created a database parallel to the official reporting system to speed up the analysis and recommend specific actions for each city. Even if a city had notified a case on a parallel basis, SESA aimed to maintain the notification flow through the official system. This database contained all cases reported by various means (phone, fax, email, and Whatsapp, among other tools) with daily updates, allowing the tracking of cases and the generation of timely information on the involvement and distribution of the epidemic.

On a weekly basis, the routine for processing SESA data basically followed three steps:

1st. Preparing epidemiological bulletins that were made available online.
2nd. Sending information to the Ministry of Health (MH).
3rd. Participating in video conferences between technicians and managers of the affected cities and the Ministry of Health of Brazil.

In February 2014, the "State Committee to Fight Measles" was created. This committee was formed by health managers and technicians of the cities facing the epidemic; coordinators of state health regions; and experts from various fields, such as epidemiologists, paediatricians, infectious disease specialists, biochemical pharmacists and media advisers. After the spread of the epidemic, consultants from the Pan American Health Organization (PAHO) and the Ministry of Health of Brazil were incorporated into the State Committee. The main purpose of the weekly meetings of this committee was to evaluate the activities and results to guide the following week's actions.

In February 2014, a follow-up vaccination campaign with MMR was started. Because the limited amount of vaccines available prevented the start a massive and indiscriminate campaign, vaccination was limited to individuals within the ages of six months to five years since the highest rate of occurrence was in this age group. The target vaccination coverage was 95% in each age group. At the end of this intervention, in December 2014, routine vaccination coverage higher than 100% was achieved. However, when homogeneity was analysed by age group, only 56% (102/184) of the cities reached 95% routine vaccination coverage for each age. This strategy was not enough to control the epidemic and caused the disease to progress to other age groups.

A dose of MMR vaccine was added to the six-month dose as part of routine vaccination coverage, and the 12-month dose was kept, according to the Brazilian vaccination calendar. This strategy was maintained until the month of July 2016, one year after the interruption of the measles virus's circulation in the state.

During the epidemic, over 50,000 samples were tested for measles from all over the state. Among the reported cases, 93% (4307/4631) were closed by laboratory testing, and 86.4% (909/1.52) of the confirmed cases had a laboratory diagnosis. The attempt was to perform viral isolation when any new city reported a case. A total of 116 D8 cases were isolated in 13/34 and 5/14 cities affected in the years 2014 and 2015, respectively.

Each suspected measles patient's blood sample was tested concurrently for dengue and rubella. In some cases, when the clinical picture was suggestive of measles and the results of the serologic test were negative or showed evidence of co-infection with dengue, clinical specimens were tested in molecular biology using RT-PCR. As of 2015, with the introduction of Chikungunya and Zika viruses in the region [21], differential diagnosis of these diseases was also performed.

3.3. 2nd period: internalization of the virus, spread to the countryside of the state (EW 11 to 42/14 – March 9 to 18 November 2014)

From March to October 2014, the number of confirmed cases declined in Fortaleza and in the metropolitan area, and the epidemic shifted to cities in the northern region of the state. The highest incidences occurred in the cities of Massapê, Uruburetama and Sobral (Fig. 3).

In the city of Uruburetama, the estimated resident population was 20,289 people. The epidemic was based at a shoe factory, and the strategy used was mass vaccination with 21,460 doses of MMR administered to local residents and workers at the company. The actions occurred within a work week and culminated in a "D" day when there was indiscriminate vaccination.

In the city of Sobral, a measles epidemic occurred in an industrial complex, which served as a source of infection for many workers who resided in neighbouring cities. This was the main mechanism of dissemination to 13 other cities.

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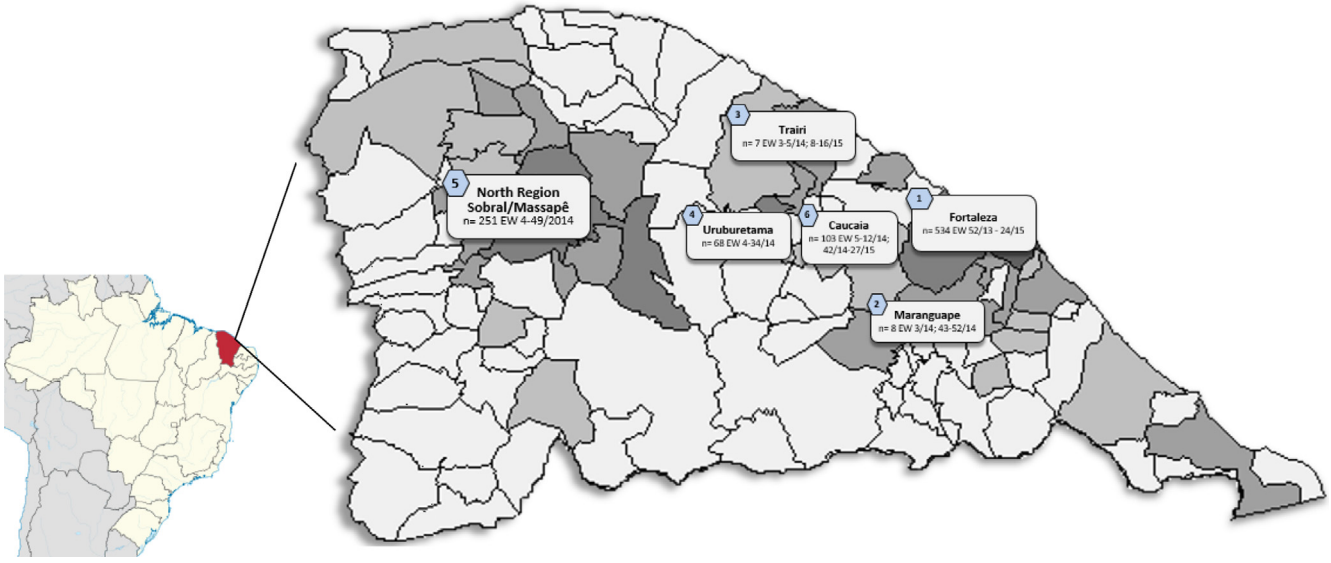

Fig. 3. Incidence of measles in Ceará, 2013–2015.

In Massapê, approximately 22,000 people aged 5–29 years were vaccinated in schools and other strategic locations where the confirmed cases had been.

Due to these vaccination actions, it was possible to interrupt the chain of transmission in the northern region in October 2014.

3.4. 3rd period: maintenance of virus transmission in the cities of Fortaleza and Caucaia (EW 43 to 53/14 – November 19, 2014, to December 31, 2014)

As the epidemic was controlled in the north, cases were again confirmed in the city of Fortaleza, affecting neighbourhoods that had not previously registered cases. In the city of Caucaia, cases also flared. During this period, activities were prioritized to contain the epidemic in these two populous cities.

In October 2014, with the worsening of the epidemiological situation and upon the recommendation of the "International Experts Committee on Measles," Ceará received PAHO, Ministry of Health and the State of Pernambuco consultants to assist in fighting the epidemic. These professionals joined the local teams and headed to the cities experiencing transmissions to determine the dynamics of local transmission and perform on-site actions.

"Given the impossibility of identifying epidemiological links, transmission chains were created from mathematical models considering the temporal link." To close the epidemiological investigation of cases that did not have a conventional immunological reaction (i.e., the elevation of specific antibodies and clinical compatibility), an Experts Committee of infectious disease specialists, immunologists, biochemists, epidemiologists and paediatricians was formed to discuss each case individually, considering the local epidemic scenario, serological studies, the concomitant occurrence of other rash diseases and vaccination history. During this period, door-to-door searches for children aged 6 months to 5 years who were not vaccinated were also performed. This activity resulted in the control of cases in this age group in the city of Fortaleza. At that time, Ceará did not have enough vaccine doses available to perform indiscriminate vaccination of the entire at-risk population.

In December, the MRC to dose 1 (D1) in children under five years of age ended, and 41,062 vaccination booklets were validated. Only 2% (850/41,062) did not have D1 with the measles component, which had been distributed in 42 cities. As the result of this action, all unvaccinated children received a dose of vaccine.

3.5. 4th period: control of transmission and evidence of virus circulation interruption (SE 01 to 27/15 – January 1, 2015, to July 6, 2015)

The fourth period coincided with the change in state management. This change generated new commitments and agreements between the state of Ceará and the Ministry of Health of Brazil, including the support of PAHO, which was instrumental in containing and controlling the epidemic.

There was finally an official announcement on the occurrence of cases of measles in Ceará. Between April and May 2015, there was a joint convocation of the press involving the three spheres of government (municipalities, the state of Ceará, and the federal government of Brazil) to achieve a more effective information campaign and greater routine vaccination coverage. This mobilization involved television and radio ads, especially in prime time, with advertising to improve public awareness of the importance of vaccination. The professionals were informed of the main symptoms of the disease and advised on the proper procedures when assisting a suspected case of measles. Later, the campaign was expanded to include other media, such as billboards and the wide circulation of vehicles, spots in sound cars and the distribution of flyers on public roads, in crowded places and in public transport terminals. For this step, the language of all the materials produced was adapted for the target audience of the campaign.

The epidemic was concentrated in the cities of Fortaleza and Caucaia. These cities have very different socioeconomic realities, and different strategies of action were designed according to the micro planning.

The "timeline" was used to inform the actions taken for measles cases and to identify the travels of suspected cases, search for contacts and new cases and provide follow-up (Fig. 4).

The failure to identify suspected cases in a timely manner was one of the determining factors for the occurrence and spread of the epidemic and for its long duration. To increase the system's sensitivity, a search was started in April 2015 for symptomatic measles patients in medical records and records of attendance. As a result, 123,812 records were reviewed from seven hospitals

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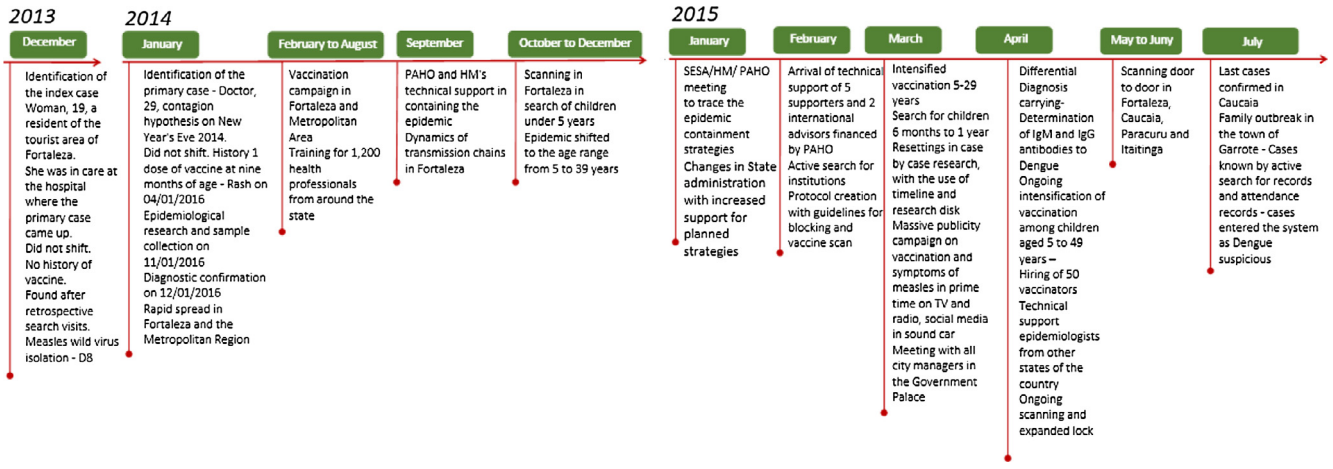

Fig. 4. Timeline of measles epidemic in Ceará, 2013–2015.

(general and/or paediatric and/or referral for infectious diseases) located in the cities of Fortaleza and Caucaia. This action identified another 57 suspected cases, two of which were later confirmed. Coupled with this scenario, in April 2015, the Zika virus was detected in Ceará. Because Zika also causes a rash and illness, it considerably increased the reports of suspected cases.

In a new MRC that was carried out in 2015, 52,216 vaccination booklets were validated. Only 1.6% (836/52.2216) did not have the D1 in the other 42 cities. During this action, 741 toddlers received a dose of the vaccine.

Between March and August, vaccination was intensified using micro planning for the population aged 5–29 years, especially populous places within large urban areas, such as popular markets, public transport terminals, schools, large enterprises, heavily populated locations, and festivals. Door-to-door searches were also conducted at times that were not traditionally worked by health teams (after 6 pm and on weekends and holidays). With this strategy, 11,465 people were vaccinated in the city of Caucaia, 77,799 in Fortaleza, 6354 in Itaitinga and 550 in Paracuru. Another strategy to attract the population for vaccination was to use the Ministry of Health national immunization mascot, "Joe, the Droplet". This advertising campaign used the slogan "Vaccination means protection."

During the door-to-door vaccination strategies, the vaccination teams used a poster with the description and images of measles symptoms in an attempt to identify possible suspected cases in the community who may not have been captured by the routine surveillance system.

As in 2015, the strategy of contact vaccination was adjusted and expanded to include contacts within the last 21 days based on the travels of each suspected case. Between the months of January and March 2015, the city of Fortaleza administered 11,410 doses of the contact vaccine, and 93% of these doses were administered to people aged five to 49 years. The city of Caucaia administered 5538 doses, and 84% were in the same age group.

As in 2015, the vaccination effort was undertaken by universities and nursing education institutions, which permitted its students to join flywheel vaccination teams responsible for the vaccination of other students at the institution and subsequently performing extramural activities in the cities of Fortaleza and Caucaia. This action resulted in the vaccination of approximately 62,000 people.

After the last confirmed case, surveillance actions were maintained for 90 days to ensure the interruption of virus circulation using epidemiological, immunization and laboratory surveillance criteria that confirmed the end of the epidemic.

4. Discussion

The global pact for measles control, which also aimed to reduce infant mortality, dates to 198 and the 42nd World Assembly of Health [21]. In 1992, Brazil anticipated and adopted the goal of measles elimination by 2000, with the implementation of the National Plan for Measles Elimination [22]. This campaign took place in 1994 in the Americas as part of the 24th Pan American Sanitary Conference [23]. Eight years after agreements between the countries and the Pan American Health Organization (PAHO) in 2002, the transmission of the last endemic strain of measles virus in the Americas, a D6 genotype, was interrupted [24].

The next challenge would be to eliminate rubella and congenital rubella syndrome (CRS) and to ensure the elimination of measles. In 2003, the effort was renewed through new goals agreed to in the Americas [25]. In 2007, the creation of national committees to verify the elimination of measles and rubella further consolidated the steps towards eliminating these diseases [26]. In 2012, the Americas developed an action plan to maintain high-quality surveillance and high vaccination coverage and to determine import risk areas, considering these as challenges in the post-elimination era.

After the last confirmed case in 1999 and after 13 years without a measles case in Ceará, there was a 20-month-long epidemic with 1052 confirmed cases in 38 cities in the northern region of the state.

In September 2001, there was an interruption of the circulation of the autochthonous D6 measles virus, which had been circulating in the region since 1995 and caused large outbreaks in Brazil, Argentina, Bolivia, the Dominican Republic and Haiti. In the same month, a new measles genotype (D9) was detected in Venezuela. In 2012, the D4 genotype that had circulated in Europe was identified more frequently, as was B3 on the African continent, and D8 and D9 in southeastern Asia and the Pacific. In the Ceará epidemics, the D8 genotype, which was circulating simultaneously and endemically in European countries such as Germany, Italy, and Croatia, was reintroduced. Genotyping in virus-eliminated regions allows the differentiation of autochthonous cases from possible imported cases, which is why it is critical to have a structure for isolating viruses.

The cases occurred in isolation, and the family itself was considered a unit; this differed from endemic periods, in which whole families became sick and many children died of the disease, suggesting a shift in the standard of infection patterns in the post-measles elimination period. There are still endemic occurrences of measles in countries in the Western Pacific, Africa, Southeast

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Asia, the Eastern Mediterranean and Europe. The Americas still face major challenges due to the frequent and continuing importation of measles cases. Between 2003 and 2014, 5077 cases of imported measles were reported, mainly in Brazil, Canada and the United States.

The vaccination actions that were implemented at the beginning of the epidemic were not enough to contain its spread since they were limited only to the direct contacts of measles cases without considering other factors involved in the management of a measles epidemic after it ended. This slow response probably contributed to the increased circulation of the virus. These fragmented actions at the beginning of the epidemic required an increased mobilization of human and financial resources, even with evidence that it is more cost effective to avoid epidemics [3–5]. Experience has shown that after the introduction of the measles virus, it is much more difficult to contain the outbreak with emergency immunization activities. It is likely that the virus circulates much faster than any public health response can react, resulting in long outbreaks in a large territory. The measles epidemic in Ceará confirmed the great infective potential of measles and its capacity to spread among susceptible people, even in a community with high routine vaccination coverage [1,16].

The case-by-case follow-up of every new suspected case and the institutional search for records and attendance records expanded the vaccination strategies for controlling the epidemic. Endemic circulation in several countries, together with globalization and a substantial flow of tourists, maintained the potential for reintroduction. The same factors have been mentioned in countries that have eliminated the disease [12,17], and the challenge for the Americas persists because of the frequent detection of imported cases [8,9].

Scanning vaccination, which allowed the use of local innovations for both the active search for suspected cases and for susceptible unvaccinated members of the population should be considered the two pillars for sustainably eliminating measles and rubella in the Americas. The challenge of reaching the unvaccinated requires innovative strategies for reaching the entire population enrolled in health services, including the floating population of approximately 3.5 million people per year [16–19]. In addition, the implementation of a register of vaccinated people (and not just the number of doses administered) will allow the accurate assessment of routine vaccine coverage and thus the ability to quickly find children who have not been vaccinated [16].

The experience with this epidemic showed that routine vaccination coverage considering the city as an evaluation unit was not enough to identify pockets of susceptibility. We need to encourage a continuous analysis of the stratified data by communities and at-risk groups and the rapid monitoring of routine vaccination coverage [13–16]. It is important to highlight that the contact vaccinations conducted in 2014 were restricted to the household contacts of suspected cases and were administered during an inappropriate period, making them ineffective for preventing new cases. Only with a sensitive surveillance system, the involvement of health professionals, homogenous routine vaccination coverage and a vaccination rate of over 95% will ensure herd immunity [5–7,14,15].

The point in the epidemic when the number of cases began to decrease clearly coincided with the point at which the activities of epidemiological surveillance, the immunization sector, coordinated communication actions, laboratory surveillance and primary care were integrated. This coordinated response reduces the chances of spreading the virus and thus the harm and the impact of a measles epidemic [19,20].

The incorporation of other actors, such as scientific societies and public and private universities, into the scenario of the epidemic, together with technical alignment at different levels of management, allowed the expansion of activities. This was potentiated using micro planning to reach segments of the population that were considered difficult to access. The experience with this epidemic indicates that this practice should be maintained and enhanced through a horizontal programme that integrates different levels of management and involves other public organisations and companies.

The main challenge for the sustainability of measles elimination in Brazil is maintaining a highly sensitive surveillance system, even with the concomitant occurrence of other rash diseases such as dengue, Zika, and Chikungunya, which can mask the occurrence of measles and delay the notification of suspected cases.

Conflicts of interest

None.

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