

## Can measles be eradicated globally?

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**Abstract** Measles is one of the most infectious diseases. Before measles vaccine was introduced, nearly everyone contracted the disease at some point in childhood. By the late 1980s, most countries had incorporated measles vaccine into their routine immunization programmes. Globally, about 800 000 children nevertheless still die from measles annually, half of them in Africa. Eradicating measles would therefore play an important role in improving children's survival. The 24th Pan American Sanitary Conference in 1994 established a goal of eradicating measles from the Americas. Progress to date has been remarkable and the disease is no longer endemic in the Americas, with most countries having documented interruption of transmission. As of November 2003, 12 months had elapsed since the last indigenous case was detected in Venezuela. This experience shows that measles transmission can be interrupted, and that this can be sustained over a long period of time. Global eradication is feasible if an appropriate strategy is implemented. Even under a new paradigm in which immunization is not discontinued after measles is eradicated, eradication will be a good investment to avoid expensive epidemics and save the lives of almost one million children annually. A world free of measles by 2015 is not a dream.

**Keywords** Measles/prevention and control/transmission/epidemiology; Immunization programs/organization and administration; Measles vaccine; Disease transmission/prevention and control; Americas (*source: MeSH, NLM*).

**Mots clés** Rougeole/prévention et contrôle/transmission/épidémiologie; Programmes de vaccination/organisation et administration; Vaccin antiorbilleux; Transmission maladie/prévention et contrôle; Amérique (*source: MeSH, INSERM*).

**Palabras clave** Sarampión/prevenición y control/transmisión/epidemiología; Programas de inmunización/organización y administración; Vacuna antisarampión; Transmisión de enfermedad/prevenición y control; Américas (*fuentes: DeCS, BIREME*).

الكلمات المفتاحية: الحصبة، الوقاية من الحصبة ومكافحتها، سرية الحصبة، وبائيات الحصبة، برامج التمنيع، تنظيم وإدارة برامج التمنيع، لقاح الحصبة، سرية الأمراض، الوقاية من سرية الأمراض ومكافحتها، القارتان الأمريكيتان.

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Voir page 137 le résumé en français. En la página 137 figura un resumen en español.

يمكن الاطلاع على الملخص بالعربية في صفحة 138.

### Introduction

Measles is one of the most infectious diseases. Before measles vaccine was introduced, nearly everyone contracted the disease at some point in childhood. Humans are the only reservoir of measles, although other primates, such as monkeys, can also be infected by deliberate inoculation in the laboratory. The most infectious phase is the prodromal, before other symptoms appear, such as fever and exanthema. Communicability diminishes rapidly after exanthema appears (1).

An attenuated live measles virus vaccine was authorized for use in the USA in 1963 and was already widely disseminated in several parts of the world by the late 1970s. This vaccine gives protection for more than 20 years, but the immunity it confers is believed to last for life (2). Its effectiveness is 90–95%. Because maternal antibodies interfere with those produced by the vaccine, the effectiveness of the vaccine increases after the first six months of age, peaking at 95–98% between 12 and 15 months of age (3). By the late 1980s, most countries had incorporated measles vaccine into their routine immunization programmes, and coverage with this vaccine has increased considerably. By 1990, the

reported global coverage of children by two years of age was about 70%.

Data from WHO indicate that measles causes 10% of deaths worldwide among under-5-year-olds. Globally, about 40 million cases of measles and 800 000 resulting deaths still occur every year, over half of them in Africa alone. Eradicating measles would therefore play an important role in improving children's survival.

Can measles be eradicated globally? Answering this requires reviewing the experiences with measles eradication in the WHO Region of the Americas. This article therefore briefly describes the strategies being implemented in the Americas to interrupt indigenous measles transmission and the results achieved so far.

### The strategy

In 1994, on the same day that the International Commission for the Certification of Poliomyelitis Eradication declared the Region of the Americas polio free, the 24th Pan American Sanitary Conference established the goal of eradicating measles from the western hemisphere (4). The rationale for the strategy used to eradicate measles was based on the epidemiology of the disease before and

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after introduction of the vaccine. In the pre-vaccine era, measles epidemics occurred every few years as soon as a pool of susceptible children provided by every birth cohort was available to fuel transmission once the virus had been introduced into a given population. Introducing the vaccine and subsequently increasing vaccination coverage during the post-vaccine era elongated the periods between epidemics; in some instances this reached several years. For example, the maximum interepidemic period was 9 years in Chile and 12 years in the USA.

Furthermore, in the pre-vaccine era, some very young children contracted measles and nearly all children did so by age five years. When the vaccine was introduced and coverage increased, the age-specific incidence increased among older children, and even young adults and some older adults contracted measles (5).

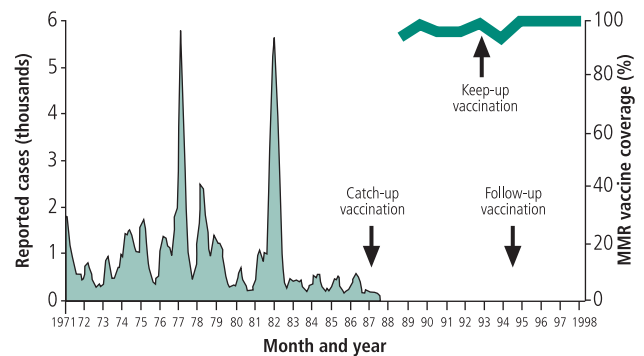
Another important factor is that the vaccine effectiveness is not 100%. Many children therefore remain susceptible because they never received the vaccine, and a small proportion of those vaccinated were primary vaccination failures and also remain susceptible. The result is that susceptible children accumulate over a few years, even with a very good immunization programme. Thus, vaccine coverage is not equivalent to population immunity.

With this background, the Pan American Health Organization (PAHO) recommended a strategy for its Member States that called for high vaccination coverage of the susceptible population at all times and effective surveillance to detect measles transmission and respond accordingly. The vaccination strategy (6) is three-pronged, as discussed below.

First, a one-time catch-up campaign, implemented during the low season for measles virus, targeting all children aged 1–14 years, to attempt to interrupt all chains of measles transmission. This age group was chosen because more than 90% of the cases were occurring in it by the time this programme started in the Americas. The second component is to maintain vaccination in the routine services to achieve the highest possible level of coverage of new birth cohorts in every district of every country to delay the accumulation of susceptible children. Nevertheless, even if coverage is high in every district, susceptible children will accumulate because some miss vaccination and a few that received the vaccine are primary failures. With average vaccination coverage of 80%, it takes five years to accumulate the number of susceptible children equivalent to one birth cohort. When this number is reached, a follow-up campaign should be undertaken among all children aged 1–4 years regardless of previous vaccination status. The third component of the vaccination strategy is therefore follow-up campaigns, designed to address the accumulation of susceptible children. These campaigns are conducted every four years and target all 1–4-year-olds, regardless of previous vaccination status, and reach the children who never received a dose of measles vaccine, while those who received a previous dose will benefit from a second one. This strategy offers a second opportunity for children to receive their first dose of measles vaccine. The first country to adopt this strategy in the Americas was Cuba, which successfully interrupted measles transmission in the late 1980s (Fig. 1).

The surveillance component was designed to be very simple, timely and sensitive to detecting outbreaks and able to be understood by every health worker, thus permitting a prompt and adequate response. Basically, if a health worker suspects that a child has measles, a trained epidemiologist should visit the child, decide whether to classify the case as suspected measles requiring

Fig. 1. Reported measles cases by month in Cuba, 1971–98 (MMR = measles–mumps–rubella)



Source: Ministry of Health, Cuba.

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further investigation and collect a blood specimen for confirmation through an immunoglobulin M capture assay. If no adequate specimen was taken but there was an epidemiological link with a laboratory-confirmed case, the case concerned would be also laboratory confirmed, otherwise it would be clinically confirmed. This last category of cases resulted from deficiencies in the surveillance system (Fig. 2).

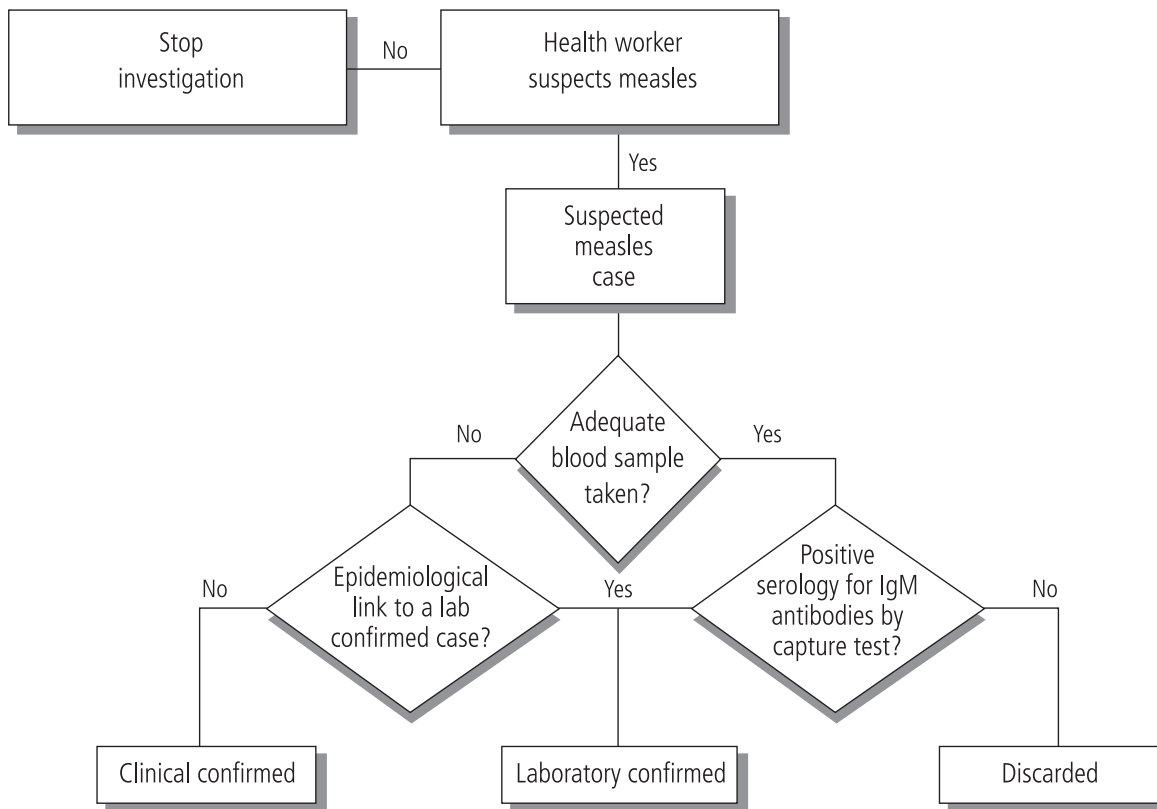
When the programme began, many cases were clinically confirmed, whereas at present nearly 100% of suspected cases are discarded because the specimens are adequate and laboratory results negative. Surveillance for measles was integrated with that for rubella to maximize the activities related to control of the latter disease. If a suspected measles case is laboratory negative, tests are performed to investigate for rubella, and vice versa for suspected rubella cases. Management indicators have been introduced, such as the proportion of suspected cases investigated within 48 hours of reporting, and the proportion of those for which adequate specimens have been collected and sent to a laboratory. In addition, urine samples are taken for each outbreak to isolate the virus. The proportion of laboratory results available within 5 days of receipt at the laboratory indicates the performance of the laboratory network. Also, periodic active searches for cases are carried out in areas that have had recent outbreaks or have low immunization coverage, have reported suspected cases for some time or have poor population access to health services.

The progress to date has been remarkable. Most countries have conducted the catch-up campaigns, achieved a very high level of coverage and are now implementing follow-up campaigns. These latter campaigns usually achieve very high coverage, exceeding 90% at the national level. Districts that are below the national average are identified, and additional mopping-up campaigns are then implemented in the districts at risk. Surveillance indicators have been kept at acceptable levels (Fig. 3). The proportion of laboratory response within five days has improved, and the laboratory-discarded suspected cases now exceed 80% (7).

## Results

In 1990, more than 240 000 cases of measles were reported in the Region of the Americas. In 1996 only 2106 cases were reported in the western hemisphere, about 50% of which were laboratory confirmed. By the end of 1996, the number of measles cases in the Americas had been reduced by 99% compared with 1990 levels. In 1997, there was a resurgence of measles in São Paulo, the only

Fig. 2. Case classification for measles



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federal unit in Brazil that did not implement a follow-up campaign scheduled in the country for 1996. An outbreak that started in early 1997, probably originating from importation of measles virus from Europe, spread to other federal units in Brazil and to several other countries in the Americas. By the end of 1997, more than 50 000 cases had been reported in the Americas, with more than 90% originating in Brazil (8).

In 1998, the number of cases declined to 14 000 but the outbreak spread to Argentina, Bolivia and eventually the Dominican Republic and Haiti. During 2001, only 545 cases were reported in the entire region, with epidemic transmission at the end of 2001 only in Venezuela and a few cases imported into the northern border areas of Colombia.

Transmission in the Dominican Republic and Haiti was interrupted in mid-2001. Of the 2548 cases reported in the Region in 2002, 94% were from Venezuela, 5% from Colum-

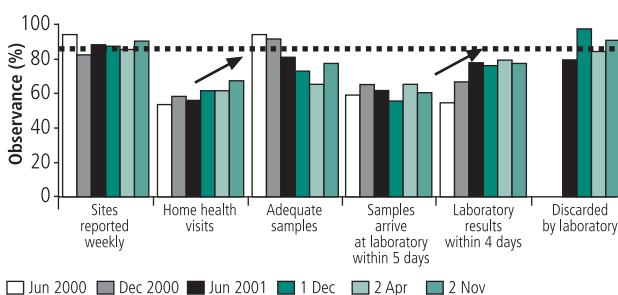
bia, and 1% from other WHO regions. The last indigenous cases in the Americas were in Colombia in week 36 and in Venezuela in week 38 of 2002. As at November 2003, 12 months had elapsed without indigenous transmission being detected anywhere in the entire western hemisphere. The genotype D9 measles virus that was imported into Venezuela has been reported to be eradicated (9).

Thus, the catch-up campaigns, the keep-up activities and the follow-up campaigns have been successful in interrupting measles transmission in the Americas.

Measles is no longer endemic in the Americas, and most countries have documented interruption of transmission. Thirty-eight of 47 countries and territories in the region have been free of indigenous measles transmission for more than two years. Measles re-emerged in the Americas in 2001–02 because the recommended strategy was not fully implemented. Most cases were in vaccinated pre-school-age children and in unvaccinated young adults, with health professionals playing a very important role in the chains of transmission. Measles re-emerged in 1997 and 1998 in Brazil for the same reason: failure to implement the full strategy.

Importation of measles into the countries that have followed the strategies PAHO recommended did not generate epidemics and only occasionally resulted in a few secondary cases. This happened, for example, in El Salvador, where the last indigenous case was in 1996. In May 2001, two young adults who had been travelling in Europe returned infected with measles that had probably been acquired in Switzerland. There was no secondary transmission despite an active search in which virtually every household in El Salvador was visited. Peru had several cases that were imported from neighbouring Bolivia during the outbreak in 2000. Only in a few instances was there a secondary case

Fig. 3. Average observance of indicators of measles surveillance in the Americas, July 2000–November 2002



Source: country reports; data as of 15 November 2002.

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within a household with an imported case. Cases in Canada and the USA have also been linked to importation from Europe. In Mexico, two cases were imported from Japan into Cancun, a very busy tourist resort, but there was no spread into the general community.

Surveillance has improved considerably throughout the Americas, and active search has not detected transmission in any country. The Dominican Republic and Haiti performed house-to-house vaccination to control a vaccine-derived polio outbreak in 2000–01. This polio outbreak was concurrent with the importation of measles into both countries, and the vaccination campaigns therefore used polio and measles vaccines. Furthermore, health workers were offered a reward of US\$ 100 if they found a case of either polio or measles during the house-to-house visits, but no case of either disease was found.

### Lessons to be learned

Although the resurgence of measles in the Americas during 1997 caused an important increase in the number of cases that had been reported in 1996, the 53 000 cases involved represent only about 10% of the cases reported in 1990. Nevertheless, important lessons can be derived from this experience.

First, the lack of a timely follow-up vaccination campaign in São Paulo in 1996 for children aged 1–4 years, combined with the low coverage of routine vaccination (keep-up) of the infants with at least one dose of measles vaccine, permitted the rapid and dangerous increase in the number of susceptible children. Second, the presence of a great number of young adults who had not been exposed to the natural infection and had never been vaccinated exacerbated the risk of an outbreak. Third, the measles virus was probably introduced into São Paulo from Europe. Finally, the city's high population density facilitated contact between those infected and the susceptible population.

The surveillance data for measles, combined with the results of molecular epidemiology studies, indicate that the countries of the Americas are exposed continually to measles virus from other regions where measles continues to be endemic.

### Conclusions

The experience of the last five years of the measles eradication programme in the Americas shows that measles transmission can be interrupted and that interruption can be sustained over a long period of time if all the countries of the Americas fully apply the vaccination strategy PAHO recommends.

The PAHO strategy has proved to be effective in achieving and maintaining the interruption of epidemic transmission in a very large geographical area such as the western hemisphere. Global eradication could be feasible if an appropriate strategy is implemented. Also, experience in the Americas has shown that although the current measles vaccine is not perfect it has been adequate to stop measles transmission. Eradicating measles will greatly reduce childhood morbidity and mortality. Even under a new paradigm in which immunization is not discontinued after measles is eradicated, eradication is a good investment to avoid expensive epidemics and, most importantly, save the lives of almost one million children annually.

However, launching a global initiative on measles eradication will require demonstrating that polio has been eradicated. Programmatic, political and financial obstacles also need to be overcome before global measles eradication is launched. Also partnerships will be essential to support governments embarking on eradication.

A world free of measles by 2015 is, however, not merely a dream. ■

**Conflicts of interest:** none declared.

### Résumé

#### L'éradication mondiale de la rougeole est-elle possible ?

La rougeole est l'une des maladies les plus contagieuses. Avant l'introduction du vaccin antirougeoleux, rares étaient les enfants qui échappaient à la maladie. Vers la fin des années 80, la plupart des pays avaient inclus la vaccination antirougeoleuse dans leurs programmes de vaccination systématique. Chaque année dans le monde, environ 800 000 enfants – dont la moitié en Afrique – meurent encore de la rougeole. L'éradication de cette maladie permettra donc d'améliorer sensiblement la survie de l'enfant. En 1994, la XXIV<sup>e</sup> Conférence sanitaire panaméricaine s'est fixé comme objectif d'éradiquer la rougeole des Amériques. Les résultats obtenus à ce jour ont été remarquables et la maladie

n'est plus endémique dans les Amériques, la plupart des pays ayant prouvé que la transmission était interrompue. Le dernier cas de transmission indigène, détecté au Venezuela, remonte à novembre 2002, ce qui montre que la transmission de la rougeole peut être interrompue, et ce sur une longue période. L'éradication mondiale est réalisable avec une stratégie adaptée. Même dans l'hypothèse où l'on poursuit la vaccination après l'éradication de la rougeole, l'éradication reste un bon investissement qui permet d'éviter les épidémies coûteuses et de sauver la vie de près d'un million d'enfants chaque année. Un monde sans rougeole d'ici 2015 n'est pas un vœu pieux.

### Resumen

#### ¿Es posible erradicar el sarampión a nivel mundial?

El sarampión es una de las enfermedades más infecciosas que existen. Hasta que se introdujo la vacuna antisarampión, casi todo el mundo contraía la enfermedad en algún momento de la infancia. A finales de los años ochenta, la mayoría de los países habían incorporado la vacuna en sus programas de vacunación sistemática. Sin embargo, cada año siguen muriendo por esa causa unos 800 000 niños en todo el mundo, la mitad en África. La erradicación del sarampión, por consiguiente, es un factor decisivo

para mejorar la supervivencia infantil. En 1994, la 24<sup>a</sup> Conferencia Sanitaria Panamericana estableció la meta de erradicar el sarampión de las Américas. Los progresos logrados hasta la fecha han sido notables, y la enfermedad ya no es endémica en las Américas, de tal manera que la mayoría de los países han confirmado la interrupción de la transmisión. A noviembre de 2003 habían transcurrido 12 meses desde la detección del último caso autóctono en Venezuela. Esta experiencia muestra que es

posible interrumpir la transmisión del sarampión, y que esa situación puede mantenerse durante mucho tiempo. La erradicación mundial es factible si se pone en práctica una estrategia apropiada. Aun bajo un nuevo paradigma en el que no se interrumpe la

inmunización una vez erradicado el sarampión, la erradicación será una buena inversión para evitar el alto costo de nuevas epidemias y salvar la vida de casi un millón de niños cada año. Un mundo libre de sarampión para 2015 no es ningún sueño.

## ملخص

### هل يمكن استئصال الحصبة من العالم؟

إذ لم تعد الحصبة متوطنة في القارتين الأمريكيتين، وأصبح لدى معظم البلدان إيقاف موثّق لسراية الحصبة. وبحلول الأول من تشرين الثاني/نوفمبر ٢٠٠٣ سيبر اثنا عشر شهراً على كشف آخر حالة بين السكان الأصليين في فيتزويلا. وتبرهن هذه الخبرة على أن إيقاف سسراية الحصبة ممكن، وأنه سيكون مضمون الاستمرار إذا ما تم تنفيذ استراتيجية ملائمة. وحتى مع النظرة الجديدة إلى عدم قطع التمنيع بعد استئصال الحصبة، فإن استئصال الحصبة سيكون استثماراً جيداً لتجنب الأوبئة الباهظة التكاليف ولإنقاذ أرواح ما يقرب من مليون طفل كل عام. إن عالماً خالياً من الحصبة بحلول عام ٢٠١٥ لم يعد حلمًا بعيد المنال.

الملخص: تعد الحصبة من أكثر الأمراض عدوائية، وقيل استعمال لقاح الحصبة كان جميع الناس تقريباً يصابون بالحصبة في فترة ما من طفولتهم. وفي نهاية الثمانينيات من القرن الماضي أدخلت معظم البلدان لقاح الحصبة في برامجها التمنيعية الاعتيادية، ومع ذلك فإن ما يقرب من ثمانمئة طفل في العالم يموتون كل عام بسبب الحصبة، ونصفهم في أفريقيا. ومن هنا سيكون لاستئصال الحصبة دور كبير في تحسين معدلات البقاء على قيد الحياة بين الأطفال. وقد وطد المؤتمر الرابع والعشرون حول صحة عموم أمريكا الذي عقد عام ١٩٩٤ هدف استئصال الحصبة من القارتين الأمريكيتين. والتقدم المحرز إلى اليوم تقدم ملحوظ،

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