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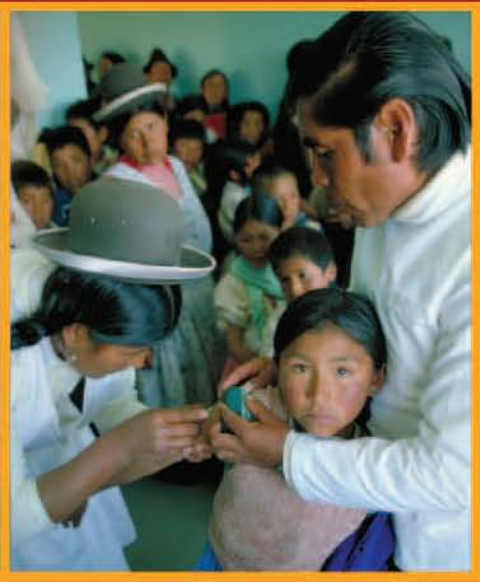

# Measles Elimination

## Field Guide

Second edition

Pan American Health Organization

Regional Office of the World Health Organization

# MEASLES ELIMINATION

## Field guide

### Second Edition

**Pan American Health Organization**

*Regional Office of the*
World Health Organization

Scientific and Technical Publication No. 605

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# ABOUT THE IMMUNIZATION FIELD GUIDES

The Expanded Program on Immunization is viewed as one of the most successful public health experiences in the Americas because it has played a pivotal role in reducing infant mortality from vaccine-preventable diseases in the Region. In fact, since the program was launched our countries stopped the transmission of wild poliovirus in the Region in 1991 and interrupted indigenous measles transmission in November 2002; they also are making significant gains in the battle to eliminate rubella and congenital rubella syndrome. In addition, national immunization programs are undertaking extraordinary efforts to identify at-risk populations and overcome inequities in vaccination. To maintain these advances and to cope with new challenges, such as the introduction of new vaccines, partnerships will have to be strengthened among governments, donor agencies, the private sector, scientific associations, and society as a whole.

To this end, PAHO is promoting the best technical quality by issuing these practical Field Guides that have been prepared by the Immunization Unit in the Family and Community Health Area. The most recent techniques presented in the Field Guides, coupled with useful illustrations, will help health workers in their efforts to control, eliminate, or eradicate diseases such as poliomyelitis, neonatal tetanus, yellow fever, diphtheria, pertussis, tetanus, *Haemophilus influenzae* type b infections, hepatitis B, measles, and rubella. The Field Guides also include standardized methods and procedures for conducting epidemiological surveillance and maintaining an up-to-date information system that makes it possible to take timely and effective decisions.

These Field Guides are based on the latest scientific information and they bring together the experience of prominent health professionals in the field. As a result, they are particularly suitable for promoting strategies that have already proven to be effective. The strengthening of prevention activities, the reduction of health inequities, and the promotion of technical expertise in vaccination services were the principles that guided the preparation of the guides.

The Expanded Program on Immunization, a joint effort of all the countries of the Americas, effectively contributes to the attainment of the Millennium Development Goals.

Dr. Mirta Roses Periago
Director
Pan American Health Organization

# PREFACE

*The Measles Elimination Field Guide* aims to provide health authorities, medical officers, and other health personnel involved in measles elimination at national, state, and local levels with a step-by-step manual for setting up and carrying out activities to eliminate measles and those activities required to sustain its elimination. The second edition of this guide incorporates experiences acquired over the past 12 years by the countries in the Region of the Americas, but can be used by any country working toward the elimination of measles. It emphasizes vaccination and surveillance strategies that are required to eliminate measles and to continually monitor progress toward achieving and sustaining such a goal. Some of the measures described may need to be adapted to local conditions. Several prototype forms are included in the annexes and can be copied or modified to meet particular needs.

Much of the information contained in this manual was taken directly from technical papers previously prepared by the Pan American Health Organization; several textbooks and other publications also were consulted. Many of these documents are listed in the bibliography at the end of this guide.

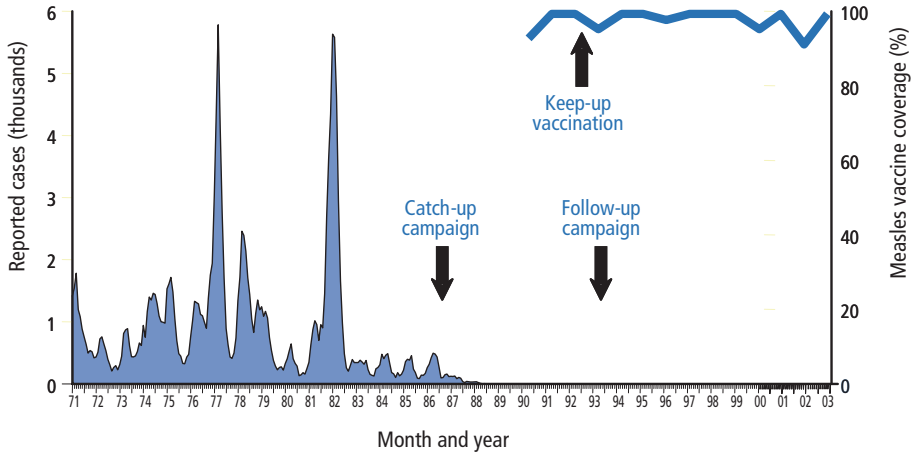
The Pan American Health Organization acknowledges the outstanding accomplishments of all the health workers in the Region of the Americas involved in measles elimination activities. In confronting the formidable challenge of eliminating one of the most infectious and lethal agents known to man, these health workers have persevered and continued to learn from their experiences. It is hoped that the lessons learned from the measles elimination experience in the Americas can be adapted and applied in all countries and regions of the world.

# 1. INTRODUCTION

## 1.1 Background

A major goal of the 1990 World Summit for Children was to reduce the number of deaths caused by measles by 95% and the number of cases by 90%, compared with pre-immunization levels. In 2002, this global goal was only partially achieved as deaths were reduced by 89% and cases by 67%. Despite the availability of a safe, effective, and relatively inexpensive vaccine for over 40 years, measles remains the leading cause of child mortality among vaccine-preventable diseases. The World Health Organization (WHO) estimated that 30–40 million measles cases and 530,000 measles-related deaths occurred worldwide in 2003.

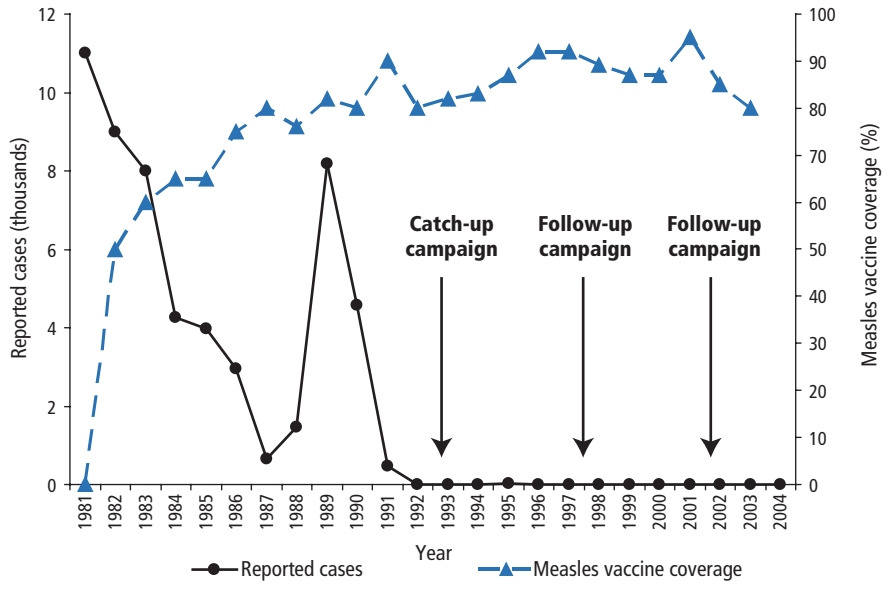
**Figure 1. Impact of mass vaccination campaigns on measles morbidity—Cuba, 1971–2003**




Source: Ministry of Health, Cuba

Nevertheless, global measles mortality decreased by 39% between 1999 and 2003 due to acceleration of measles control strategies throughout the world. Many of those strategies had been developed and first used during the early 1990s in the Americas, when the countries of the Caribbean and Latin America adopted a three-tiered vaccination approach combining routine vaccination ("keep up" vaccination) and mass vaccination campaigns ("catch-up" and "follow-up" campaigns, see Section 5). This approach had a major impact on measles virus circulation and corrected many of the shortcomings experienced by previous measles prevention programs.

**Figure 2. Impact of mass vaccination campaigns on measles morbidity—English-speaking Caribbean, 1981–2004**




Source: Caribbean Epidemiology Centre, PAHO

In light of the certification of polio eradication in the Americas and the success demonstrated by the Caribbean countries in interrupting measles virus circulation (Figures 1 and 2), the Ministers of Health of the Americas adopted in September 1994 the goal of measles

virus elimination from the Western Hemisphere by the year 2000 (Resolution XVI of the XXIV Pan American Sanitary Conference).

Between 1999 and early 2004, countries throughout the Region of the Americas embarked on accelerated measles elimination activities, using strategies defined in the first edition of this field guide. The intensification of measles elimination activities took place within the wider context of accelerated activities of the Expanded Program on Immunization (EPI), and clearly built upon the accomplishments of the polio elimination program. Implementing a measles elimination program has clearly been an ambitious task, requiring the collaboration of ministries of health, the private sector, nongovernmental organizations, and multilateral and bilateral international partners. At the time of publication of this field guide, the goal of measles elimination in the Americas appears close at hand. The last occurrence of widespread measles virus transmission dates to an outbreak in 2001–2002 in Venezuela and Colombia; the last confirmed case in this outbreak had a date of onset of 21 November 2002. During 2003 and 2004, imported and import-related cases occurred sporadically in half a dozen countries.

The primary aim of the *Measles Elimination Field Guide* is to provide health personnel involved in measles elimination efforts at national, state, and local levels with a guide for implementing elimination activities and for sustaining achieved progress. It incorporates knowledge acquired from the measles elimination activities conducted throughout the Caribbean and Latin America between 1987 and 2004, and emphasizes issues related to enhanced surveillance, mass immunization campaigns, mop-up efforts, and outbreak response activities. Routine immunization activities are also described since such activities are crucial for sustaining advances in measles elimination. Prototype forms are included in the annexes, and they can be copied or modified to meet particular local needs.

**Note on terminology:** The terminology for measles has been a source of some confusion. The proper scientific term in English is rubeola, although the illness has commonly been referred to as 10-day measles, hard measles, red measles, and morbilli. However, in Spanish, *rubéola* means German measles (rubella). Alternative Spanish terms are *sarampión* or *morbilli* for measles and *sarampión alemán* for rubella. The French terms are *rougeole* for measles and *rubéole* for rubella.

# 2. EPIDEMIOLOGY

## 2.1 Infectious Agent

Measles virus is a member of the genus *Morbillivirus* of the *Paramyxoviridae* family. The virus appears to be antigenically stable—there is no evidence that the viral antigens have significantly changed over time. However, sequence analysis of viral genes has shown that there are distinct lineages (genotypes) of wild-type measles viruses. When considered along with epidemiological information, identification of a specific virus genotype can suggest the origin of an outbreak. For instance, the genotype of the virus isolated

during the 2001–2002 outbreak in Venezuela was a close match to a virus isolated in cases imported into Australia from Indonesia as early as 1999. Vaccination protects against all wild-type genotypes.

The measles virus is sensitive to ultraviolet light, heat, and drying.

## 2.2 Occurrence

Measles produces a significant amount of illness, death, and disability in developing countries. Measles caused approximately 7% of the estimated 11.6 million deaths that occurred in 1995 in children aged 4 years and under in developing countries. Of the estimated 614,000 measles-related deaths occurring in 2002, 312,000 (51%) and 196,000 (32%) were in Africa and South-East Asia, respectively.

Measles occurs worldwide in distinct seasonal patterns. In temperate climates, outbreaks generally occur in late winter and early spring. In tropical climates, transmission appears to increase after the rainy season.

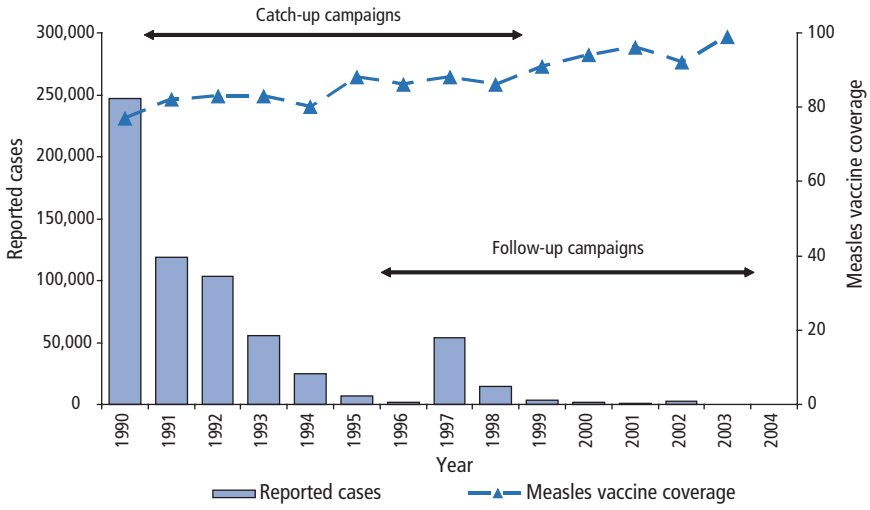
In developing countries with low vaccination coverage, epidemics often occur every two to three years and usually last between two and three months, although their duration varies according to population size, crowding, and the population's immune status. Outbreaks last longer where family size, and hence the number of household contacts, is large. In the absence of measles vaccination, virtually all children will have been infected with measles by the time they are 10 years old.

Countries with relatively high vaccination coverage levels usually have five to seven year periods when case numbers remain small. However, if the number of susceptible persons becomes large enough to sustain widespread transmission, explosive outbreaks may occur.

The introduction of measles vaccine in the Americas in the 1960s resulted in a marked decrease in the number of reported measles cases. The creation of the Expanded Program on Immunization (EPI) in 1977, and the ensuing increase in vaccination coverage, contributed to a further drop in the number of reported measles cases and a tendency toward longer intervals between epidemic years (see Figure 3).

Between January 2000 and August 2004, 5,078 measles cases were confirmed in the Americas. The majority of the cases occurred during a 2000 outbreak on the island of Hispaniola

**Figure 3. Measles cases and coverage* with measles-containing vaccines—The Americas, 1990–2004**




*Coverage data for 1 year old children
Source: Immunization Unit, PAHO

(1,752 or 30% of cases) and during a 2001–2002 outbreak in Venezuela and Colombia (2,654 or 52% of cases). In 2003 and 2004, approximately 100 cases were reported each year. Most of these cases were directly or indirectly linked to importations of the measles virus from other regions of the world.

### 2.3 Transmission

Measles virus is transmitted primarily by respiratory droplets or airborne spray to mucous membranes in the upper respiratory tract or the conjunctiva. Common-source outbreaks associated with airborne transmission of measles virus have been documented.

### 2.4 Reservoir

Humans are the only natural hosts of measles virus. Although monkeys may become infected, transmission among them in the wild does not appear to be a mechanism by which the virus persists in nature.

### 2.5 Incubation

The incubation period is approximately 10–12 days from exposure to the onset of fever and other unspecific symptoms, and 14 days (with a range of 7–18 days, and, rarely, as long as 19–21 days) from exposure to the onset of rash.

### 2.6 Communicability

Measles can be transmitted from four days before rash onset (i.e., one to two days before fever onset) to four days after rash onset. Infectivity is greatest three days before rash onset.

Measles is highly contagious. Secondary attack rates among susceptible household contacts have been reported to be 75%–90%. Due to the high transmission efficiency of measles, outbreaks have been reported in populations where only 3% to 7% of the individuals were susceptible. Whereas vaccination can result in respiratory excretion of the attenuated measles virus, person-to-person transmission has never been shown.

### 2.7 Immunity

Prior to the availability of measles vaccine, measles infection was virtually universal. Infants are generally protected until 5 to 9 months of age by passively acquired maternal measles antibody. Immunity following natural infection is believed to be lifelong, and vaccination with measles vaccine has been shown to be protective for at least 20 years.

### 2.8 Changing Epidemiology

Since the introduction of effective measles vaccines, the epidemiology of measles has changed in both developed and developing countries. As vaccine coverage has

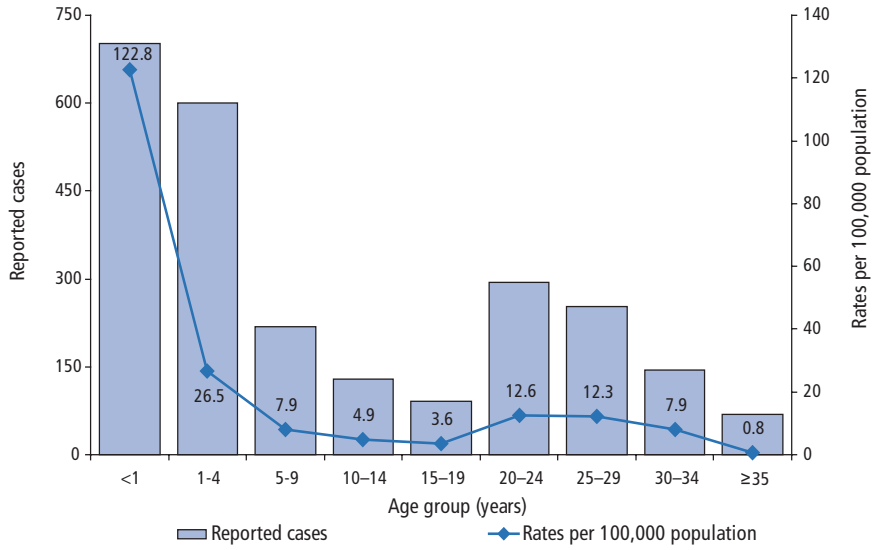
increased, there has been a marked reduction in measles incidence; and, with decreased measles virus circulation, the average age at which infection occurs has increased.

Even in areas where vaccine coverage rates are high, outbreaks may still occur. Periods of low incidence (the "honeymoon" effect) may be followed by a pattern of periodic measles outbreaks, with an increase in the number of years between epidemics. Outbreaks are generally due to the accumulation of persons susceptible to measles virus, including both unvaccinated persons and those who were vaccinated but failed to seroconvert. Approximately 15% of children vaccinated at 9 months of age and 5%–10% of those vaccinated at 12 months of age fail to seroconvert, and are thus not protected after vaccination.

After the introduction of measles vaccine during the 1960s, countries that had achieved high vaccine coverage experienced a 98% or greater reduction in the number of reported cases. However, periodic measles epidemics continued to occur, especially in large urban areas. These outbreaks occurred primarily among unvaccinated preschool-aged children, but cases and outbreaks were also reported among fully vaccinated school-aged children.

For instance, unvaccinated infants and preschool-aged children were at greatest risk for measles infection during the 2001–2002 outbreaks that occurred in Venezuela (Figure 4). Cases among older children and adults also occurred and likely involved those individuals who had not been vaccinated and had previously escaped natural measles infection because of decreasing measles incidence. Since measles vaccine is less than 100% effective, vaccinated individuals might also have contracted measles.

**Figure 4. Measles cases and age-specific attack rates—Venezuela, 2001–2002**




Source: Ministry of Health, Venezuela

In large urban areas, even where measles vaccine coverage is high, the number of susceptible infants and children may still be sufficient to sustain transmission. Conditions such as high birth rates, overcrowding, and the influx of large numbers of susceptible children from rural areas can facilitate measles transmission.

In areas where measles remains endemic, a large proportion of cases occur in children aged less than 1 year, an age group that also has the highest age-specific measles case-fatality rates. In those areas, only a brief period (or "window of opportunity") exists between the waning of maternal antibody and children's exposure to circulating measles virus.

## 3. CLINICAL ASPECTS

During periods of high measles virus circulation, measles infection can be diagnosed clinically with reasonable accuracy. However, the large number of rash-like illnesses that may occur in childhood makes laboratory support the key to definitive diagnosis, especially during periods of low measles incidence. A summarized description of the pathogenesis of measles virus infection and its clinical manifestations is presented in Figure 5.

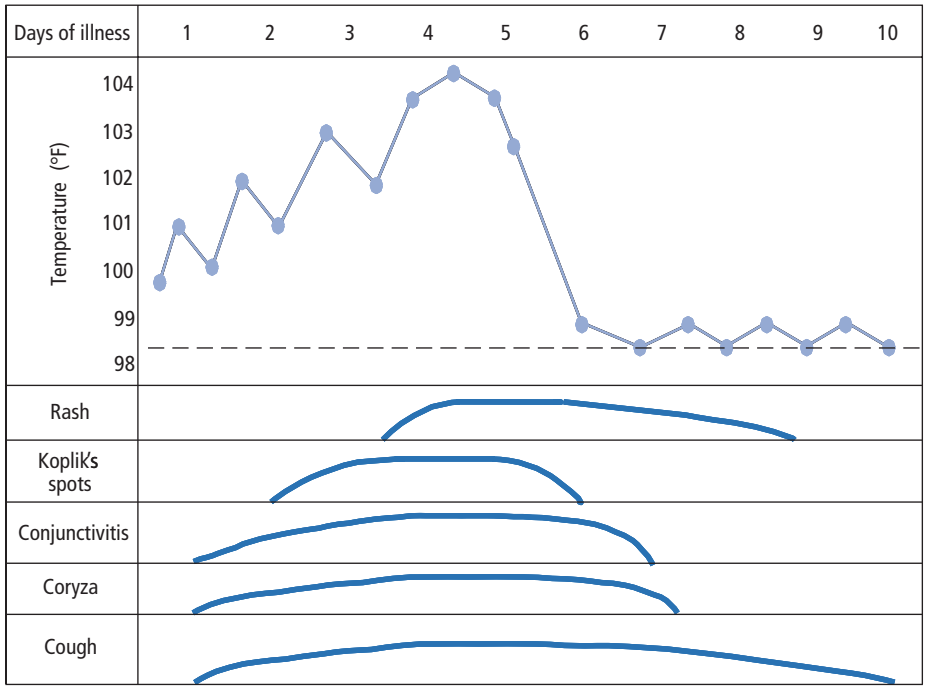
**Figure 5. Pathogenesis and clinical manifestations of measles virus infection**

| INFECTION | INCUBATION | COMPLICATIONS |
|---|---|---|
| Aerosol<br>Nasopharynx respiratory epithelium<br>↓ | Exposure<br>↓ | |
| Regional lymph nodes<br>↓ | | |
| Blood<br>↓ | **Primary viremia** (2 to 3 days after exposure) | |
| Lymph-reticular system, spleen, liver, bone marrow<br>↓ | ↓ | |
| Blood<br>↓ | **Secondary viremia** (5 to 7 days after exposure, lasts 4 to 7 days)<br>↓ | |
| Kidney, skin, upper and lower respiratory tract, brain, giant cells, mononuclear cells, mucosa<br>↓ | Leucopenia<br>↓ | |
| ↓ | **Prodrome** (10–12 days after exposure, lasts 2–4 days)<br>Rhinitis, cough, inflamed conjunctivae, tonsillitis, mild fever, red buccal membrane, Koplik's spots<br>↓ | |
| Immunological response<br>↓ | **Rash** (14 [7–21] days after exposure, lasts 4–9 days)<br>Macular (starting on face, spreading to body)<br>High fever<br>Rash fading<br>Fever decreasing | Otitis media (ear infection)<br>Pneumonia<br>Diarrhea<br>Encephalitis<br>Corneal scarring & blindness |
| Antibody development<br>↓ | ↓ | |
| (Continued excretion in nasopharynx and urine)<br>↓ | Desquamation | |
| Decreasing virus in organs<br>↓ | Temperature normal<br>Desquamation | |
| Virus cleared<br>↓ | ↓ | ↓ |
| **IMMUNITY** | **RECOVERY** | **DEATH, DISABILITY** |

## 3.1 Clinical Features

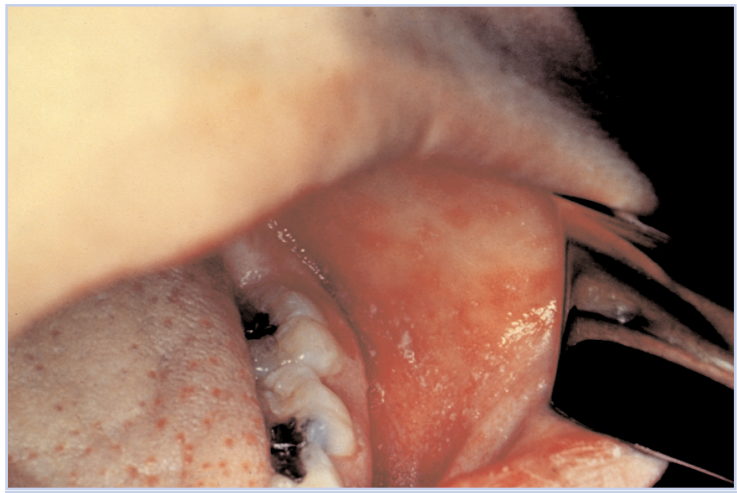
**Prodrome and general symptoms.** Measles infection presents with a two to four day prodrome of fever, malaise, cough, and runny nose (coryza). Conjunctivitis and bronchitis are commonly present. Although there is no rash at the onset, the patient is shedding virus and is highly contagious. A harsh, nonproductive cough is present throughout the febrile period, persists for one to two weeks in uncomplicated cases, and is often the last symptom to disappear. Generalized lymphadenopathy commonly occurs in young children. Older children may complain of photophobia and, occasionally, of arthralgia. A typical clinical course of measles is illustrated in Figure 6.

**Figure 6. Typical clinical course of measles virus infection**




Reprinted from: Krugman S. Diagnosis of Acute Exanthematous Diseases. In: Gershon AA, Hotez PJ, Katz SL (eds.) *Krugman's Infectious Diseases of Children,* 11th ed. Figure 45-1, p. 927, Copyright 2004, with permission from Elsevier.

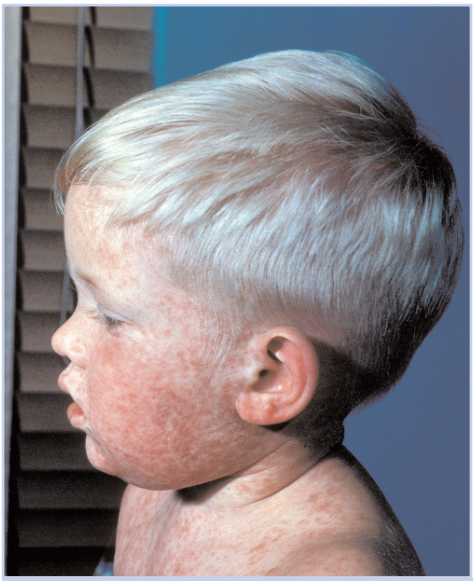
**Koplik's spots.** Koplik's spots may be seen on the buccal mucosa in over 80% of cases, if careful daily examinations are performed shortly before rash onset. Koplik's spots are slightly raised white dots, 2–3 mm in diameter, on an erythematous base (Figure 7). Initially, there are usually one to five of these lesions, but as rash onset approaches there may be as many as several hundred. They have been described as resembling "grains of salt sprinkled on a red background." The lesions appear one to two days before rash onset and persist for two or three days, disappearing soon after rash onset.



Credits: Centers for Disease Control and Prevention

**Figure 7. Koplik's spots in a measles patient**

**Rash.** Within two to four days after the prodromal symptoms begin, a characteristic rash made up of large, blotchy red areas initially appears behind the ears and on the face (Figure 8). At the same time a high fever develops. The rash peaks in two to three days and becomes most concentrated on the trunk and upper



Credits: Centers for Disease Control and Prevention

**Figure 8. Maculopapular rash in a measles patient**

Credits: Centers for Disease Control and Prevention

**Figure 9. Skin desquamation in a measles patient**

extremities. The density of the rash can vary. The rash typically lasts from three to seven days and then fades in the same pattern as it appeared and may be followed by a fine desquamation. Whereas rash may be less evident in children with dark skin, desquamation generally is apparent (Figure 9). Some children develop severe exfoliation, especially if they are malnourished.

### 3.2 Differential Diagnosis

Many illnesses are accompanied by fever, rash, and a variety of nonspecific symptoms. In examining for measles, it is important to consider rubella, scarlet fever, exanthema subitum (roseola), dengue fever, and the early stages of chickenpox in the differential diagnosis (Annex 1). Moreover, there are other conditions that may present in a similar form, including erythema infectiosum (fifth disease), enterovirus or adenovirus infections, Kawasaki's disease, toxic shock syndrome, rickettsial diseases, and drug hypersensitivity reactions. Table 1 compares clinical and epidemiological characteristics of measles, rubella, dengue, erythema infectiosum, and roseola.

Modified forms of measles, with generally mild symptoms, may occur in infants who still have partial protection from maternal antibody, and occasionally in persons who only received partial protection from the vaccine. Atypical forms may occur in persons who were vaccinated with a formalin-inactivated (killed) vaccine, but such a vaccine has not been used since the mid-1960s.

### 3.3 Complications

Complications from measles include otitis media, laryngotracheobronchitis, pneumonia, diarrhea, febrile seizures, encephalitis, and blindness. Children aged less than 5 years and adults over 20 years of age are at greater risk of serious complications; malnutrition and immunodeficiency disorders also increase that risk. It was estimated that among the cases reported in the United States between 1987 and 2000, diarrhea occurred in 8% of cases, otitis media in 7%, and pneumonia in 6%. Overall, 29% of the cases had some type of complication.

**Respiratory infections.** Laryngotracheobronchitis or "measles croup" was reported in as many as 32% of children hospitalized in the United States. Bacterial pathogens, particularly *Staphylococcus aureus*, were isolated in up to one-half of the cases. Pneumonia is the most common severe complication from measles and is associated with the greatest number of measles-related deaths. It may be due to the measles virus alone or to secondary infection with adenoviruses or bacterial organisms.

**Table 1. Comparison of clinical and epidemiological characteristics of measles and its differential diagnoses**

| Illness | Measles | Rubella | Dengue fever | Erythema infectiosum | Roseola (exanthema subitum) |
|---|---|---|---|---|---|
| **Etiology** | Measles virus | Rubella virus | Dengue viruses, serotypes 1 to 4 | Human parvovirus B 19 | Human herpes virus 6 |
| **Incubation period (days)** | 7–21 | 12–23 | 3–14 | 4–14 | 5–15 |
| **Fever** | Yes | Yes | Yes | Yes | Yes |
| **Rash**<br>**Characteristics**<br>**Distribution**<br>**Duration** | Yes<br>Maculopapular<br>Cephalocaudal<br>Four to seven days | Yes<br>Maculopapular<br>Cephalocaudal<br>Four to seven days | Yes<br>Maculopapular<br>Centrifugal<br>Three to five days | Yes<br>Maculopapular<br>Cephalocaudal<br>Five to ten days | Yes<br>Maculopapular<br>Thorax and abdomen<br>Hours to days |
| **Conjunctivitis** | Yes | No | Yes | No | No |
| **Cough** | Yes | No | No | No | No |
| **Coryza** | Yes | No | No | Yes | No |
| **Retroauricular adenopathy** | No | Yes | Yes | No | Yes |
| **Serological test to detect acute infection** | IgM | IgM | IgM | IgM | IgM |
| **Infection outcome during pregnancy:**<br>**Abortion**<br>**Congenital defects** | <br>Yes<br>No | <br>Yes<br>Yes | <br>No<br>No | <br>Yes<br>No | <br>No<br>No |
| **Vaccination as preventive measure** | Yes | Yes | No | No | No |

Adapted from Buchy, 2005; Caumes, 1993; Frieden and Resnick, 1991; Harn, 1989; Heymann, 2004; Krugman, 2004; Remington and Klein, 2001.

**Diarrhea and malnutrition.** Diarrhea may develop both during and following acute measles illness, and is an important component of the burden caused by measles for children in developing countries. Measles infection is more severe among children who are already malnourished, particularly those with vitamin A deficiencies. Moreover, measles may exacerbate malnutrition because of decreased food intake due to malaise, increased metabolic requirements in the presence of fever, or the mistaken belief of parents and health practitioners that a child's food should be withheld during an acute illness. Undernutrition may lead to or worsen vitamin A deficiency and keratitis, resulting in a high incidence of childhood blindness following measles outbreaks.

**Neurological complications.** These occur in 1 to 4 of every 1,000 infected children. The most common manifestation is febrile seizures, which are not usually

associated with persistent residual sequelae. Postinfectious encephalomyelitis occurs a few days after rash onset in 1 to 3 of every 1,000 infected persons, especially in adolescents and adults. One-fourth of the patients die and one-fourth have lifelong neurological sequelae, including severe mental retardation, motor impairment, and blindness. Subacute sclerosing panencephalitis (SSPE) is a rare (incidence of approximately 1 per 100,000 measles cases), chronic, degenerative neurological disorder associated with the persistence of the measles virus in the central nervous system. It may develop several years after a measles infection.

**Case-fatality.** In industrialized countries, the case-fatality rate for measles is approximately 1 per 1,000 reported cases. In developing countries, the case-fatality rate has been estimated at between 3% and 6%; the highest case-fatality rate occurs in infants 6 to 11 months of age, with malnourished infants at greatest risk. These rates may underestimate the true lethality of measles because of incomplete reporting of outcomes of measles illness, such as deaths related to chronic diarrhea that occur after the acute illness has passed. In addition, some deaths may be missed when death certificates are miscoded or hospital records are incomplete. In certain high-risk populations, case-fatality rates as high as 20% or 30% have been reported in infants aged less than 1 year. Young age, crowding, underlying immunodeficiency, vitamin A deficiency, and lack of access to medical care are all factors leading to the high case-fatality rates observed in developing countries.

### 3.4 Treatment

There is currently no specific treatment for measles infection. Administration of vitamin A to children with measles has been shown to decrease both the severity of disease and the case-fatality rate, and WHO recommends that vitamin A be administered to all children with acute measles. One dose (50,000 I.U. for infants aged less than 6 months, 100,000 I.U. for infants aged 6–11 months, and 200,000 I.U. for children aged ≥ 12 months) should be administered on the day of measles diagnosis and one dose should be administered the following day.

Supportive treatment should be provided for a number of measles complications. For uncomplicated cases, fluids (such as oral rehydration solution), antipyretics, and nutritional therapy are commonly indicated. Many children require four to eight weeks to fully recover their pre-measles nutritional status.

Other measles complications, such as diarrhea, pneumonia, and otitis media, should be treated following the WHO protocol for Integrated Management of Childhood Illness.[1]

[1] Protocol available online at http://www.who.int/child-adolescent-health/publications/referral_care/contents.htm (1/15/2005).

# 4. MEASLES VACCINES

The original measles vaccines approved for use in children in 1963 were either inactivated (killed) or attenuated live virus vaccines. These vaccines are no longer in use. The vaccines currently employed in most countries are further-attenuated live measles virus vaccines, which are generally derived from the original Edmonston strain. The Moraten strain vaccine is used principally in the United States, while the Schwartz strain is the predominant vaccine used in many other countries.

All vaccine preparations containing standard titers of live measles virus may be used. The combined measles-mumps-rubella (MMR) vaccine is preferred to ensure that immunity is obtained against all three viruses. The use of MMR vaccine in measles campaigns will result in the reduction of rubella and mumps circulation among children and decrease the incidence of congenital rubella syndrome (CRS). Programs that add rubella vaccine to their schedule should develop a complementary comprehensive rubella control plan to ensure that women of childbearing age and men are also protected against rubella.[2]

## 4.1 Immunity

Serologic studies have demonstrated that measles vaccines induce seroconversion in about 95% of children aged 12 months or older, i.e. children who have lost all passively acquired maternal measles antibody. Although antibody titers are lower, the development of serum antibodies following measles vaccination mimics the response following natural measles infection. The peak antibody response occurs six to eight weeks after natural infection or vaccination. Immunity conferred by vaccination against measles has been shown to persist for at least 20 years and is thought to be lifelong for most individuals.

For combined vaccines, studies indicate that the antibody response to all antigens is equivalent to the response when each is administered separately.

## 4.2 Schedule

Routine immunization schedules should recommend that the first dose of measles vaccine be administered to children aged ≥ 12 months. However, if an importation or an outbreak occurs and a significant proportion of the cases are among infants aged less than 9 months, consideration may be given to lowering the age of measles vaccination to 6 months. Nonetheless, all infants vaccinated before their first birthday **must** receive another dose of measles-containing vaccine at 12 months of age and at least one month after the first dose of measles vaccine.

[2] See Pan American Health Organization, *Elimination of Rubella and Congenital Rubella Syndrome: Field Guide*," Scientific and Technical Publication No. 606 (Washington, D.C., PAHO, 2005).

All children should have a second opportunity to receive a measles-containing vaccine. This opportunity may be provided either as a second dose in the routine immunization schedule, for instance, before entering school, or through periodic mass vaccination campaigns (see Section 5.3, "'Follow-up' vaccination campaigns").

Revaccination of previously vaccinated persons with measles vaccine alone or in combination with rubella and mumps vaccines is not contraindicated. The vaccines have an excellent safety record when given to persons who have previously received one or more doses of measles vaccine. Studies have shown that when measles virus is reintroduced into a community, it can spread even among populations with high rates of vaccination coverage. During such events, revaccination provides an additional safeguard.

Simultaneous administration of MMR and other live or inactivated vaccines at separate anatomic sites is expected to produce similar immune responses or rates of adverse events among vaccinated persons. For example, measles-containing vaccines and yellow fever vaccines can be administered simultaneously at separate anatomical sites using separate syringes.

### 4.3 Contraindications

Measles-containing vaccine can be safely and effectively administered to children with mild acute illnesses, such as low fever, diarrhea, and upper respiratory tract infections. However, severely ill children with high fevers should not be vaccinated until they have recovered.

Malnutrition is **not** a contraindication, but rather a strong indication for measles vaccination. If a malnourished child is infected, the disease may aggravate his/her nutritional status and increase the chances of complications or death.

There are only two contraindications to measles vaccination. People who have experienced an anaphylactic or severe hypersensitivity reaction to a previous dose of MMR vaccine or its component vaccines or who have experienced an anaphylactic reaction to neomycin should not be vaccinated. Caution should be exercised with people who have had anaphylactic reactions to gelatin or gelatin-containing products.

In countries where human immunodeficiency virus (HIV) infection is prevalent, infants and children should be immunized with the EPI antigens according to standard schedules. This also applies to individuals with asymptomatic HIV infection. Screening for HIV infection prior to vaccination should not be conducted. For persons with symptomatic HIV infection who lack evidence of measles immunity, the potential risks of measles vaccination must be weighed against the potential risk of being exposed to circulating measles virus. However, patients with **severe** immunosuppresion caused by HIV infection or another condition (e.g., congenital immunodeficiency, hematologic or generalized malignancy) should not be vaccinated.

Since MMR vaccine and its component vaccines contain live viruses, they should not be administered to pregnant women. This contraindication is based on theoretical rea-

sons, as there is currently no evidence to suggest that children born to pregnant women who received these vaccines during pregnancy are adversely affected. Moreover, prospective studies of the offspring of women vaccinated with rubella vaccine during pregnancy have not found vaccination to be a risk factor for development of CRS.

MMR vaccine **can** be administered safely to people allergic to eggs, to children of pregnant mothers or who have contact with pregnant women, to women who are breast-feeding, and to people with immunodeficient family members or household contacts.

### 4.4 Adverse Events Associated with Vaccination

The MMR vaccine and its component vaccines are generally extremely safe. Adverse events range from pain and induration at the injection site to rare systemic reactions such as anaphylaxis. They tend to occur among people who have never been vaccinated before, and are very rare after revaccination. Adverse events relate to the single component vaccines.

**Measles.** Approximately 5% to 15% of infants vaccinated with measles vaccines may develop a low-grade fever beginning 7–12 days after vaccination and lasting for one to two days; approximately 5% develop a generalized rash beginning 7–10 days after vaccination and lasting for one to three days. These reactions are generally mild and well tolerated. Neurological complications following vaccination are reported to occur in less than 1 in 1 million vaccinees (see Table 2). The benefit of using the vaccine clearly outweighs the costs associated with having the disease, both in human and monetary terms.

**Table 2. Occurrence of adverse reactions following measles vaccination compared with occurrence of same symptoms/syndrome among measles patients**

| Adverse reactions | Reaction rate following vaccination | Rate among measles patients (natural infection) | Range of relative risk disease/vaccine |
|---|---|---|---|
| Fever ≥ 39.4 °C | 1/16–1/6 | 1 | 6–16 |
| Rash | 1/100–1/5 | 1 | 5–100 |
| Febrile convulsions | 1/2,500–1/100 | 1/200–1/100 | 1–25 |
| Encephalitis/encephalopathy (other neurological disorders) | 1/1,000,000–1/17,600 | 1/1,000 | 17.6–1,000 |
| Subacute sclerosing panencephalitis (SSPE)[a] | 1/1,000,000[a] | 1/200,000–1/50,000 | 5–20 |
| Thrombocytopenic purpura | 1/30,000–1/40,000 | < 1/3,000 | > 10[b] |

[a] No case of SSPE has been proven to be caused by measles vaccine.
[b] Estimated rate.

Thrombocytopenia has been reported within two months of vaccination with MMR. Data from Europe indicate a frequency of thrombocytopenia of 1 case per 30,000 to 40,000 vaccinated susceptible cases. The clinical course is generally transient and benign.

**Mumps.** Adverse events following mumps vaccination are rare, the most common being parotitis and mild fever. Aseptic meningitis is one of the most frequent complications of natural mumps infection, and many attenuated mumps vaccine strains retained the ability to cause aseptic meningitis. However, meningitis rates after vaccination are much lower than those after natural infection and sequelae of postvaccine meningitis are rare.

**Rubella.** Adverse events associated with rubella vaccine include rash, fever, and lymphadenopathy 5 to 12 days after vaccination in a small percentage of children. In addition, joint pain, usually in small peripheral joints, may occur; it tends to be more frequent in postpubertal females. Joint involvement usually begins 7 to 21 days after vaccination and is transient. Central nervous system complications with fever and thrombocytopenia have been reported, but no cause-and-effect relationship with the vaccine has been established.

### 4.5 Dosage and Administration

Measles vaccine is lyophilized and reconstituted with sterile water immediately prior to administration by injection. Given as a single antigen or combined with mumps and rubella vaccines, the volume of injection is 0.5 ml and should be administered subcutaneously in the anterior thigh, although it may also be administered in the upper arm. Each 0.5 ml dose of reconstituted vaccine should contain a minimum infective dose of at least 1,000 viral $TCID_{50}$ (median tissue culture infective doses). Other live and inactivated bacterial and viral vaccines can be administered simultaneously without problem. After administration, needle and syringe should be disposed of safely.

### 4.6 Storage and Supply

Before reconstitution, measles vaccine is relatively heat stable. Measles, measles and rubella (MR), and MMR vaccines should be stored at 2°C to 8°C. At these temperatures, a minimum infective dose can be maintained in the unreconstituted vaccine for two or more years. Storage at temperatures over 8°C will reduce potency, and breaks in the cold chain that result in temperatures higher than 37°C may render the vaccine completely ineffective. Although not harmful to the vaccine, storage at –15°C to –25°C is neither essential nor recommended. However, diluent vials must never be frozen. When the manufacturer supplies the vaccine packed together with its diluent, the product should always be stored at 2°C to 8°C. If cold chain space permits, diluents supplied separately may safely be stored at 2°C to 8°C.

At the local level, vaccine should always be placed in the center of a storage refrigerator used only for vaccines. To assist in temperature maintenance in the event of a power failure, bottles or other containers full of water should also be stored on the lower shelves of the refrigerator. Care should be taken to minimize the frequency with which the refrigerator door is opened.

Measles-containing vaccine should only be reconstituted with the diluent provided by the manufacturer. Temperature of the diluent should be between 2°C and 8°C to avoid heating the vaccine. After reconstitution, the vaccine becomes extremely sensitive to light and heat. Reconstituted vaccine must be kept in a dark place at a temperature of 2°C to 8°C, and must be discarded within eight hours of reconstitution or at the end of the session, whichever comes first. Vaccine should never be left at room temperature, especially in tropical climates. When used in the field, it should be transported on dry or wet ice in insulated containers.

Effective distribution of potent vaccine in sufficient quantities is critical to the success of a measles elimination program. All locations that provide immunization should have a sufficient vaccine supply on hand to last until the next shipment is likely to be received. This generally means that a supply for one to three months should be available at the local level, for three to six months at the regional and state levels, and for six to twelve months at the national level. Order and supply dates should be checked to determine whether previous vaccine shipments were received before the vaccine supply was exhausted. Expired vaccine should be discarded. Recent monthly usage rates should be compared with the amount of vaccine remaining to determine if the vaccine on hand can be used up prior to its expiration date.

### 4.7 Cold Chain

If cases of measles occur in individuals who have been vaccinated, or in areas where mass campaigns were carried out and/or coverage rates in 1 year old children are high, the adequacy of the cold chain should be checked because there may be a problem with loss of vaccine potency. A special study may be warranted for this purpose.

During mass campaigns special attention must be paid to establishing and maintaining a cold chain that is equipped to handle the increased quantity of vaccine. In particular, it is necessary to ensure that, at all levels, sufficient amounts of ice, appropriate storage capacity (for example, through the use of local ice houses), and adequate individual refrigerators are available. In addition, power backup systems need to be present.

On visits to any facility where vaccine is stored, the following should be reviewed (see also Box 1):

- Vaccine availability;
- Vaccine expiration dates; and
- Cold chain maintenance and logistics.

### Box 1. CHECKLIST FOR STORAGE OF MEASLES-CONTAINING VACCINES

- Is there a designated person in charge of the handling and storage of vaccines? Is there a back-up person?
- Is there a vaccine inventory log that documents vaccine name and number of doses received, date the vaccine was received, arrival condition of vaccine, vaccine manufacturer and lot number, and vaccine expiration date?
- Was the last vaccine shipment received with ice packs surrounding all sides? Was the temperature of the vaccine recorded when the last shipment was received?
- Is the refrigerator working properly? Is there a thermometer, and does it work properly? Is the temperature between 2°C and 8°C? If the temperature is not in the appropriate range, was a problem found and has it been reported to a technician?
- Is there a log posted where temperatures are recorded twice daily? Is there a record of encountered problems, corrective actions taken, and outcomes?
- Is the interior of the refrigerator tidy?
- Is any expired vaccine being stored? Is the vaccine supply stocked so that the newest vaccine of each type (with the longest expiration date) is placed behind the vaccine with the shortest expiration date?
- Is there enough diluent for the vaccine, and is it appropriately stored?
- Are there enough cold boxes for routine as well as outreach activities? Are the boxes in good condition? Do they close properly and seal tightly? Are there enough frozen ice packs for the number of cold boxes being used?
- Are extra containers of water kept in the refrigerator to stabilize temperature?
- Which steps are taken in case of a refrigerator failure?
- If the refrigerator is not electric, is there enough gas or kerosene to last until the next order is expected?

## 4.8 Vaccine Efficacy and Effectiveness

Vaccine efficacy may be defined as how well a vaccine performs under the idealized conditions of a pre-marketing evaluation or a controlled clinical trial. Vaccine effectiveness, on the other hand, is considered to be the ability of a vaccine to provide protection under the normal conditions of a public health vaccination program.

Since no vaccine is 100% effective, not all persons given measles vaccine are necessarily protected against measles. Therefore, following an importation of the measles virus or during a measles outbreak the occurrence of measles cases among persons with documentation of measles vaccination is to be expected. If vaccination coverage is high, a significant number of cases may occur among vaccinated persons. The occurrence of measles cases in these persons often leads to doubts about the effectiveness of measles vaccine.

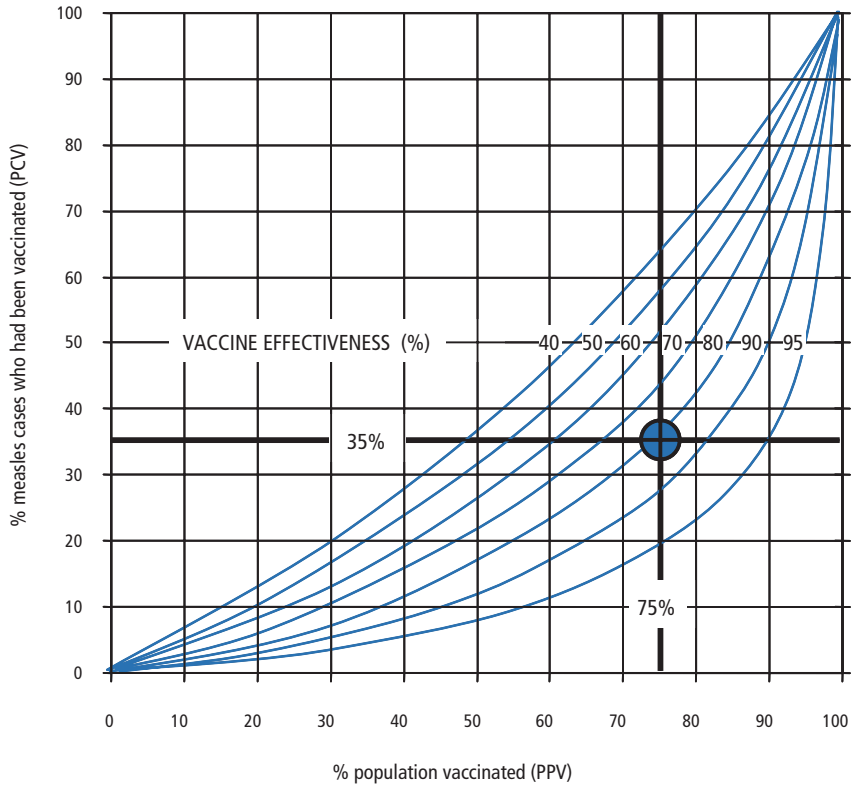
Several approaches can be used to estimate vaccine effectiveness. They include prospective cohort trials and case-control studies as part of an outbreak investigation. These methods are time-consuming and their discussion is beyond the scope

of this guide. However, an alternative method has been developed which allows a rapid estimation of vaccine effectiveness when the proportion of cases occurring in vaccinated individuals (PCV) and the proportion of the population that is vaccinated (PPV) are known. The curves in Figure 10 indicate the vaccine effectiveness levels based upon the distributions of PCV and PPV.

Figure 10 also shows an example in which the percentage of cases with a known measles vaccination status who received one or more doses of measles vaccine (PCV) was 35.9%, and the percentage of the population at risk (<10 years of age) who were vaccinated (PPV) as established by prior coverage assessments was 75%. Two straight lines are plotted on the graph and their intersection is marked with a circle. Since the circle lies between lines describing vaccine effectiveness of 80% and 90%, respectively, vaccine effectiveness in this example is estimated to be approximately 82%.

Low effectiveness levels, generally below 80%, may indicate problems with either the production of the vaccine or the cold chain. While this method does not provide an exact estimate of vaccine effectiveness, it allows health authorities to assess whether further evaluation is necessary.

**Figure 10. Estimation of measles vaccine effectiveness**




Source: Orenstein WA, et al. Field-evaluation of vaccine efficacy. *Bull WHO* 1985;63(6):1055–1068.

## 5. VACCINATION STRATEGIES TO ACHIEVE AND SUSTAIN MEASLES ELIMINATION

Vaccination of each successive birth cohort with a single dose of measles vaccine delivered through routine health services was a strategy originally used in many countries to control measles. While vaccine coverage increased markedly, measles outbreaks continued to occur.

Since measles vaccine is less than 100% effective and coverage is rarely universal via routine health services, an accumulation of non-immune children result over time. With each successive birth cohort, the number of children susceptible to

measles inevitably increases, including both children who were never vaccinated and those who were vaccinated but failed to respond to the vaccine. **The buildup of susceptible children over time in a population is the most serious obstacle to measles elimination.** High vaccination coverage through routine health services is essential, yet that alone is clearly not sufficient for measles elimination.

To improve measles control, a number of countries have adopted a vaccination schedule that recommends two doses of a measles-containing vaccine. The first dose is mainly given at or after 12 months of age; the second dose is often given when children start school. For those countries with sufficient resources, a well-developed health services delivery system, and school attendance by the majority of children, this schedule reduces the number of susceptible children and ultimately interrupts measles transmission.

However, the routine addition of a second dose is not an appropriate strategy for measles elimination in those countries where large segments of the population do not have access to routine health services and/or where many children do not attend school. A two-dose schedule is intended, in fact, to protect the 5% to 10% of children who were vaccinated but failed to respond to the vaccine; and the majority of second doses are given to children who are already protected. Unfortunately, children who never received the first routine dose of measles vaccine are also those who are unlikely to receive the scheduled second routine dose.

To rectify this shortcoming, the Pan American Health Organization (PAHO) developed a three-tiered vaccination strategy. Its implementation allowed the interruption of transmission of the measles virus in the Region of the Americas as of November 2002.

The three main components of the PAHO vaccination strategy can be described as follows:

- First, measles virus circulation in a community is rapidly interrupted by conducting a one-time-only **"catch-up"** measles vaccination campaign over a wide age cohort of infants, children, and adolescents.
- Second, to maintain the interruption of measles virus circulation, routine immunization programs (or **"keep-up"** vaccination) **must** provide measles vaccine to at least 95% of each new birth cohort of infants before the age of 2 years in every district of the country.
- Finally, to counter the inevitable buildup of children susceptible to measles, periodic **"follow-up"** vaccination campaigns among preschool-aged children are carried out every four years.

In addition to these three components, special intensive efforts, known as **"mop-up"** vaccination, may be required to provide measles vaccine to children living in

high-risk areas who missed routine vaccination and also escaped vaccination during the "catch-up" and "follow-up" campaigns.

When the PAHO vaccination strategy is fully implemented, virtually all children will receive one dose of measles vaccine, and most will receive more than one dose. Indeed, the PAHO strategy offers a second opportunity for preschool-aged children to receive measles vaccine. The paramount objective of the strategy is, therefore, to ensure that as many infants and children as possible receive at least one dose of measles vaccine. Each component of the strategy is described in detail below.

### 5.1 "Catch-up" Measles Vaccination Campaigns

The "catch-up" measles vaccination campaign is a one-time-only vaccination activity conducted over a short period of time across a wide age cohort of children. The goal is to achieve high levels of population immunity, thereby rapidly interrupting chains of measles virus transmission in a geographic area. These campaigns should be conducted during periods of low measles transmission.

All children aged 1 to 14 years, **regardless of vaccination history or history of measles disease,** are targeted for measles vaccination. Even if immunization levels are high among one-year-old children, older children may not have been vaccinated or may not have had measles. Indeed, several outbreak investigations conducted in areas with strong immunization programs and high measles vaccine coverage among one-year-old children have found that older children and adolescents are likely to be at relatively high risk for measles and are often responsible for infecting their younger siblings.

"Catch-up" campaigns should be carried out within a brief time frame, usually one week to one month. The campaign is planned and coordinated at the national level by the Ministry of Health and implemented by personnel of state and local health services (see Box 2). Before the campaign begins, sufficient supplies of vaccine and financial resources should be secured so that funds will be available to health officials at the district level, where the vaccination effort is undertaken.

Intensive social mobilization, for instance through mass media communication, is necessary to attract the target population to the vaccination sites. Health officials can take advantage of the campaign to deliver other vaccines, such as oral poliovirus vaccine (OPV), diphtheria, pertussis, and tetanus (DPT) vaccine, or pentavalent vaccine. Essential to the success of vaccination campaigns is strong collaboration among the government, nongovernmental organizations, and the private sector; these entities are led by a national Inter-Agency Coordinating Committee (ICC). Moreover, a detailed logistics plan and proper social communication will increase the probability of success. Such campaigns result in a rapid increase in population immunity, and, if high enough coverage is achieved, measles virus circulation can be interrupted.

## Box 2. CHECKLIST FOR PLANNING AND CONDUCTING A "CATCH-UP" CAMPAIGN

| | |
|---|---|
| 1. | Develop a preliminary plan for the campaign with a general time line of activities. |
| 2. | Prepare micro-plans at district level and aggregate required resources at national level. |
| 3. | Discuss resource availability within Ministry of Health and with other cooperating agencies. |
| 4. | Obtain further political commitment, including that of local leaders. |
| 5. | Obtain professional community commitment. |
| 6. | Hold social communication workshop to prepare guidelines for campaign. |
| 7. | Determine if a sufficient supply of vaccine is available, and if there is sufficient refrigeration space for vaccine and other essential supplies on their arrival. |
| 8. | Determine if cold chain is sufficient to reach remote areas. |
| 9. | Ministry of Health to designate a planning/coordination committee including a chief medical officer, an epidemiologist, EPI manager, health educator, central vaccine storekeeper, and procurement officer. |
| 10. | Planning/coordination committee to plan and develop national guidelines and refine time line of activities, including overall strategy and policy, types of promotion, and locations and methods of vaccine delivery. |
| 11. | Order measles-containing vaccine and other EPI vaccines, if included. Include disposable syringes with needles, containers for disposing of used syringes and needles, vaccine carriers, cold boxes, forms and stationery for keeping records. |
| 12. | Order material for social mobilizations, such as banners, posters, and T-shirts, and make arrangements to access media. |
| 13. | Seek assistance, especially in promotion, through schools, social workers, health educators, community groups, government, nongovernmental agencies, and influential community members. |
| 14. | Prepare special strategies to gain access to hard-to-reach groups, including grassroots and neighborhood-level involvement. |
| 15. | Health officials to explain details of program over radio and television, including panel discussions and newspaper coverage. |
| 16. | Distribute vaccines, syringes with needles, needle destructors, vaccine carriers, cold boxes, forms, and stationery. |
| 17. | Conduct final briefings and discussions to ensure that all staff—including drivers, teachers, health educators, social workers, community groups, and government and nongovernmental agencies, as well as influential members of communities—know their responsibilities. |
| 18. | Check to ensure that health centers, schools, and all other places where the vaccine will be administered are prepared with staff and the necessary supplies. Emphasize keeping accurate records to be able to derive pre- and post-campaign coverage statistics. |
| 19. | Officials of the government to officially launch the program over radio and television the day before the campaign begins. |
| 20. | Carry out rapid coverage monitoring. |
| 21. | Ensure adequate and proper supervision for guidance and corrective actions. |
| 22. | Calculate coverage achieved among children < 1, 1–4, 5–9, and 10–14 years of age if applicable. |
| 23. | Hold meeting of planning/coordination committee to report outcome; include coverage achieved, problems encountered, solutions implemented, and problems outstanding. |
| 24. | Distribute final report to all stakeholders. |

Children between the ages of 5 and 14 who attend school can generally be vaccinated through the school system. Preschool-aged children and those who do not attend school are more difficult to reach. Vaccinations should be offered at many sites in addition to the traditional clinics. Locales such as churches, community centers, markets and shopping areas, plazas, schools, transportation centers, and other easily accessible areas where people congregate should be considered.

Special attention should be paid to high-risk areas, districts, or municipalities where routine coverage levels are below the national average. Attention should also focus on populated peri-urban areas, populated border areas, and tourist areas (where importations are likely to enter a country). It may be necessary to assign additional personnel and logistical resources to these areas to address problems such as inadequate access or poorly staffed and equipped health services.

Once a "catch-up" campaign has been completed, the coverage achieved by every district should be analyzed. Those districts with low coverage rates should carry out supplementary vaccination activities, including door-to-door vaccination (see Section 5.4 on "mop-up" efforts).

**Mobilizing the community.** Achieving and sustaining measles elimination requires active community members participation. The community members need to be made aware of the benefits of eliminating measles and what it takes to sustain the absence of measles in their community; they also must be convinced that they can contribute to this goal (see Box 3). Community resources—human, material, and financial—should be sought to staff clinics, provide publicity, store vaccine, furnish freezers, and support volunteers.

### Box 3. KEY GROUPS TO CONTACT DURING THE PLANNING OF MASS VACCINATION CAMPAIGNS

- All schools and preschools
- Religious organizations
- Local organizations, mothers' groups, parent/teacher associations
- Volunteer groups
- Rotary and Lions clubs
- Medical and specialty associations
- Health providers, doctors, clinics, and pharmacies of the private health sector
- Government officials at all administrative levels

Community leaders, such as political and religious authorities and school officials, should be contacted as soon as possible during the planning stages of a mass campaign. They should be made aware that by quickly implementing vaccination activities for an entire district or larger geopolitical unit, more individuals will be protected, thereby helping to achieve/sustain measles elimination in their area. For areas with measles transmission, community leaders should also understand that vaccination activities can help to prevent measles cases and deaths. They should be informed of the activities and offered a role in them. The briefing provided should be simple and direct, emphasizing the following specific points:

- Thanks to vaccination activities, measles is no longer common in the Americas.
- To keep measles out of the Americas, periodic campaigns are needed to maintain high protection levels in the community in order to prevent imported measles cases from causing outbreaks.
- A campaign is necessary to vaccinate all children in the community quickly.
- Community mobilization should complement resources from the health sector and should provide volunteers.
- Help is needed to determine how best to access hard-to-reach and underserved populations, and when and where to hold clinics and to train volunteers.
- Assistance is needed to access community equipment for storing ice packs and/or vaccine, to distribute posters and flyers, and to set up committees within the community to deal with mass media, business contributions, churches, etc.

**Grassroots/neighborhood involvement.** One of the principal aims of any campaign should be to identify and reach groups of children who are underserved by or have difficult access to health services. Such pockets of underserved or hard-to-reach children may be in urban or rural areas and may include children who migrate with their parents for seasonal labor and children of indigenous populations. Volunteers need to go door-to-door to inform parents of the upcoming campaign and to encourage them to bring their children to the vaccinating center during the campaign.

Volunteers should inquire whether any problem would keep the parents from bringing children to a center, such as lack of transportation or lack of a babysitter for older children. The volunteer should help arrange for transport or other assistance. It is best to train a volunteer coordinator for each geographic area. This activity works best when each volunteer knows exactly the number of houses he or she is responsible for and keeps records of the visits, using a standardized data collection form. It is critical that volunteers revisit the homes on the day or days when vaccination is offered, just prior to and during the events. A variety of motivational techniques can be used to reward volunteers, and local clubs may be a good source of such rewards.

Youth groups and other volunteer groups are helpful in distributing flyers and other materials. Simple messages should be developed, and television and radio stations should be requested to provide public service announcements.

### 5.2 Routine Vaccination Services ("Keep-up" Vaccination)

After the initial "catch-up" campaign, routine immunization services should assure that all infants receive one dose of measles-containing vaccine as soon as possible

after their first birthday. Without high coverage through routine immunization services, the population of children susceptible to measles will rapidly expand and increase the probability of a large measles outbreak, should the virus be reintroduced. **High measles vaccine coverage in every new birth cohort through routine immunization services is absolutely necessary if the interruption of measles virus circulation is to be maintained over time.**

Various approaches are used to ensure that at least 95% of each new birth cohort receives measles-containing vaccine. These include:

- Improving access to vaccination services;
- Integrating vaccination services within routine health services;
- Reducing missed vaccination opportunities;
- Reducing dropout rates;
- Utilizing infant immunization tracking systems;
- Conducting special outreach activities, including door-to-door vaccination, when necessary;
- Developing school programs and school immunization laws.

In addition, national program managers should identify high-risk districts and develop micro-plans of action. These plans should be funded and contain the necessary activities to ensure that all children in the district are vaccinated. Special attention needs to be given to the hard-to-reach and underserved communities such as isolated rural areas, rapidly growing peri-urban neighborhoods, dispersed populations, or groups of individuals (for example, indigenous populations) who do not routinely use health services for various reasons. Special outreach sessions will be required to provide the needed vaccines to such populations.

The efficiency of routine vaccination activities can be monitored by conducting monthly reviews of the immunization records of one-year-old children (population aged 12–23 months). The reasons for failure to receive vaccination should be determined and vaccination strategies should be adapted.

**Vaccination coverage assessment.** Vaccination coverage should be analyzed regularly at the municipality, county, or district level. Where possible, birth cohorts should be monitored closely on a regular basis. Community-based surveys of community vaccination coverage that are based on statistical sampling are not generally advisable, as they are time-consuming and labor-intensive and divert critical resources which can be better used to improve vaccination coverage.

However, measles vaccination coverage should be assessed every 6 months at the health facility and district level by reviewing records of performed vaccinations. Cov-

erage data from each district should be aggregated at the provincial and national level on a quarterly or semi-annual basis, and districts should be categorized by coverage level (e.g., <50%, 50%–79%, 80%–94%, and ≥95%). Districts that present coverage below 90% should conduct "mop-up" activities.

In addition, "rapid coverage monitoring" should be carried out in all communities as an ongoing supervisory activity, and is an important strategy to be pursued to ensure the highest coverage levels are achieved. During the visit to the four areas, immunization status of five children aged 4 years or less are reviewed by consulting vaccination records and interviewing parents (see Annex 2). Since coverage should be 95% in all districts, almost all children encountered should be vaccinated. The presence of two or more unvaccinated children among the 20 children assessed should alert the health center staff that coverage may be inadequate. Although rapid coverage monitoring is not a formal assessment and one cannot calculate coverage with this method, it should be part of all supervisory visits. In a specific area, staff from another location should carry out the monitoring to avoid any bias in the results.

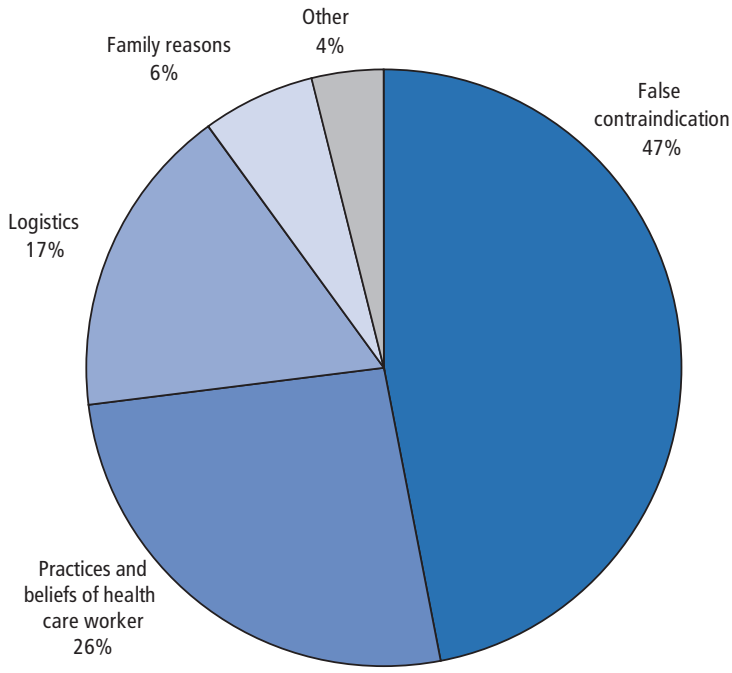
The use of rapid coverage monitoring is essential for quickly determining if an area needs to be revisited by vaccination teams in order to vaccinate children who were missed. Rapid coverage monitoring is also useful during campaigns. Since it can be carried out rapidly by any health worker, it should be incorporated in all campaigns, regardless of the campaign type. After vaccination has been completed in an area, another team can quickly visit the completed area and determine if there are any unvaccinated children. The presence of two or more unvaccinated children implies that not all children were reached, and the area needs to be revisited by the vaccination team.

**Missed opportunities for vaccination.** A missed opportunity for vaccination occurs when a child eligible for vaccination does not receive a measles-containing vaccine (or another vaccine) while visiting a health center or a vaccinating site. Studies of missed opportunities for vaccination are important in determining whether eligible children are missed and for what reason. For instance, studies may indicate that health personnel are misinformed on contraindications for measles vaccination. Corrective measures will ensure that whenever children have contact with the health care system, all vaccines they may need are administered. Indirectly, monitoring missed opportunities for vaccination also promotes integration of health services.

Missed opportunities are generally due to one or more of the following causes (see Figure 11):

- False contraindications to vaccination, including mild fever, diarrhea, vomiting, colds, and coughing, often prevent health workers from vaccinating children, despite the existence of clear national guidelines in this regard. The health workers erroneously fear that these symptoms will be exacerbated by the vaccine.
- Health workers often do not remember to ask whether a child who visits a clinic for some other reason is fully vaccinated. Other times, they may be reluctant to open a multi-dose vial of vaccine for a single child because they believe it would be a waste of resources.
- The supply and distribution of vaccines to health centers is sometimes inadequate.
- The limited hours or days during which some health centers are open is commonly cited as a factor that has prevented children's access to vaccination services.
- Family beliefs, religion, or past negative experiences with vaccination are also sometimes cited as reasons for missed opportunities.

**Figure 11. Reasons for missed vaccination opportunities**




Source: Based on studies carried out in the Region of the Americas between 1988 and 1990, PAHO

## 5.3 "Follow-up" Vaccination Campaigns

However efficient the "catch-up" and routine immunization efforts are, measles-susceptible preschool-aged children will accumulate over time. Two major factors contribute to this buildup of susceptible children. First, measles vaccination coverage for each birth cohort will almost always fall short of reaching all children. Second, measles vaccine effectiveness is at best 95%, and some children fail to seroconvert following vaccination.

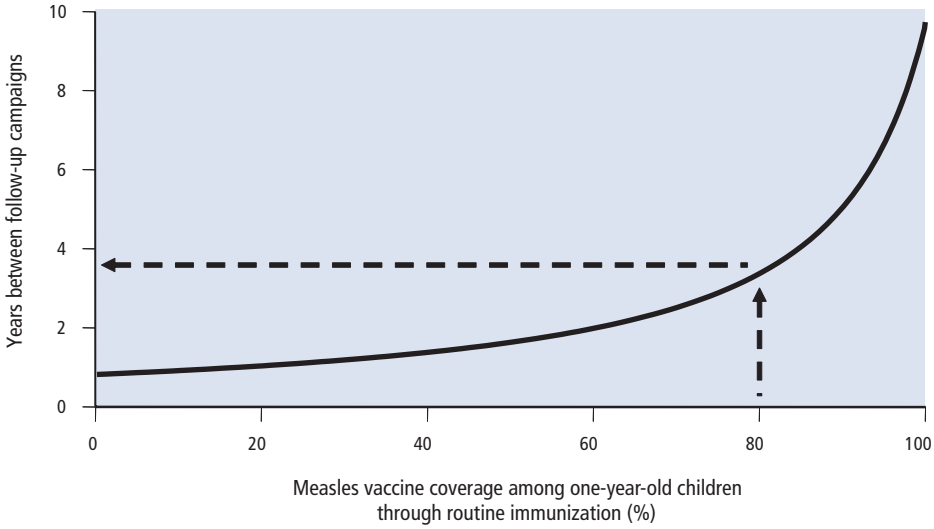
The example of a country with a population of 20 million and 500,000 births per year illustrates the buildup in susceptibles. If 90% of children aged 1 year receive measles vaccination through routine health services, and assuming 90% vaccine

effectiveness, only 405,000 children (500,000 x 0.9 x 0.9, or 81%) in each birth cohort will be protected against measles and 95,000 children (19%) will remain susceptible to measles. Thus, 95,000 children will be added each year to the pool of measles-susceptible children. In approximately five years, the number of measles-susceptible children present in the total population will approximate the number of children in an average birth cohort. This large number of measles-susceptible children will increase the risk of a large measles outbreak should the virus be reintroduced through an importation.

Thus, the PAHO measles vaccination strategy recommends that periodic "follow-up" vaccination campaigns be conducted among preschool-aged children whenever the estimated number of measles-susceptible preschool-aged children (aged 1–4 years) approaches the size of an average birth cohort. The interval between campaigns will depend upon the vaccination coverage obtained among infants through routine services since the last campaign (Figure 12). If only 60% coverage is obtained, a "follow-up" vaccination campaign would be needed approximately every two years; if 80% coverage, approximately every four years; and if 90% coverage, approximately every five years. In practice, these campaigns are conducted every four years and target all children 1–4 years of age.

"Follow-up" campaigns are conducted in a manner similar to that of the "catch-up" campaigns described above, with the exception that the target age group is narrower. For example, if four years have passed since the "catch-up," the target for the "follow-up" will be children 1–4 years of age. As with a "catch-up" campaign, after a "follow-up" campaign there may be remaining pockets of susceptible children. Therefore, it may be necessary to carry out "mop-up" vaccination efforts, as discussed in the next section.

**Figure 12. Estimated interval between follow-up measles vaccination campaigns**




Adapted from: de Quadros CA, et al. Measles elimination in the Americas: evolving strategies. *JAMA* 1996; 275:224–229. Copyright © 1996. American Medical Association. All rights reserved.

## 5.4 "Mop-up" Vaccination Efforts

After the "catch-up" and "follow-up" campaigns have been conducted, pockets of unvaccinated children may still remain, especially in disadvantaged urban areas and

in hard-to-reach rural areas. Protecting these children requires intensive vaccination efforts, which may include door-to-door vaccination. These special efforts are referred to as "mop-up" vaccination.

"Mop-ups" usually include the same age group that was targeted in the mass campaign. High-risk areas are usually selected on the basis of coverage results from the campaign. Selection may also be based on other criteria, such as:

- Poor measles surveillance or failure to report suspected fever/rash illnesses;
- Difficult access to health services;
- Large concentrations of urban poor, especially with frequent migration;
- Tourist centers; and
- Large concentrations of indigenous populations.

Although varying approaches for implementing "mop-ups" are used in urban, peri-urban, and rural areas, the overall principles remain the same. Initially, some basic information is quickly assessed:

- Population data (by age group);
- Estimated number of households;
- Maps (as current as possible) showing the urban, rural, or other geographic divisions in detail, including the number of households per block or other unit; and
- Measles immunization coverage by health district.

When the number of houses, the number of children living in the houses, the distance between them, and the topography of the area (hills, mountains, or rivers) are known, it is then possible to calculate the number of vaccinators and supervisors required, as well as how long the "mop-up" effort will last. Estimates must also be made regarding needs for vaccine carriers, ice, transportation, supplies, etc.

A field supervisor (one for each 10–15 vaccinators) should be assigned to ensure that no areas or blocks of houses are left unvisited and that all children in the target age group are vaccinated. The supervisor also must ensure that the logistics of moving vaccinators and supplies are well planned. Experience has shown that a supervisor is most effective when he/she goes along with vaccinators rather than covering large areas in a vehicle on his/her own. At the end of the day all supervisors should meet with the campaign coordinator(s) to review and discuss accomplishments and problems and to make any adjustments that may be necessary for the next day. In rural areas, supervision methods should be adjusted to the topography and size of the area covered (see Box 4).

### Box 4. IMPORTANT CONSIDERATIONS FOR MEASLES MOP-UP EFFORTS

1. **To properly plan the distribution of personnel, supervisors must be familiar with the areas to be covered**, that is, which areas have more commercial buildings and less family housing, and which neighborhoods have a higher concentration of children.
2. In urban areas one vaccinator can generally **vaccinate between 50 and 80 children per day going door-to-door** (vaccinators generally do not fill out vaccination card histories during mop-up efforts).
3. Because of possible fatigue and **logistical considerations in hilly areas**, many vaccinators should be assigned to cover these areas quickly and in the early morning hours. This will permit them to descend as the morning progresses and complete the less hilly areas in the afternoon. In very warm climates, provision of water must be taken into account.
4. Perhaps the most underestimated task, and one which is sometimes difficult to organize, is the **freezing of large quantities of ice overnight** to have ready for the vaccine carriers on the day of the campaign. This task requires careful advance planning.
5. Training of both health workers and community volunteers **needs to be carried out quickly**. Training of community volunteers should be done one or two days before the start of vaccination activities to reduce volunteer dropout.
6. On the first morning of the door-to-door vaccination, it is advisable that **operations be decentralized** and that the vaccinators and supervisor start work immediately at the designated locations, so that critical time is not wasted transporting personnel to their respective vaccination sites.

At the end of the "mop-up" effort, the total number of children who have been vaccinated should be tallied for each health center, post, or unit. This total should be compared to the goal. If there are pockets of unvaccinated children, teams of vaccinators accompanied by supervisors should return to the households during a time, for instance in the evening, when the children are likely to be there.

The results of the "mop-up" vaccination should be made known to the community as soon as they are available. The health team should provide community leaders with any other information they may find useful. The local radio station should be requested to air the results of the "mop-up" and to congratulate the community for its participation.

### 5.5 Vaccination of "High-risk" Groups

Numerous examples exist of chains of transmission during outbreaks traced to an unvaccinated health care worker who had contact with a patient being treated for measles. Medical institutions (e.g., inpatient and outpatient, public, and private) should ensure that all their workers are immune to measles and rubella—regardless of whether they are medical or nonmedical, paid or volunteer, full-time or part-time, student or nonstudent, or with or without patient-care responsibilities. **All susceptible health workers should receive MMR vaccine.**

Other workers considered at high risk and who can contribute to virus circulation are those working in the tourist industry (e.g., hotels and airports) as they may have contact with individuals coming from endemic areas. An outbreak that occurred in 1998 in Argentina was linked to an airport worker who came into contact with an infected tourist. Likewise, persons working in the transportation industry are at risk for contact with infected persons and should also be vaccinated. Measles susceptibility status in personnel of these industries should be reviewed, and susceptible workers should be vaccinated.

The measles elimination vaccination strategy primarily targets children. However, a small proportion of adolescents and young adults may have been spared from natural measles infection and never received measles vaccination, and thus remain susceptible to measles. For practical purposes, persons born before 1960 in most countries of the Americas can be assumed to have been exposed to naturally circulating measles virus and thus be immune to the disease. Therefore, the overwhelming majority of adults are already immune and most susceptible adults are at low risk for being exposed to measles virus. Countrywide mass campaigns among adults targeting only measles are generally not recommended. However, if the age distribution observed in an outbreak shows that a large proportion of patients are adults, targeted vaccination of adults may be warranted. Each country will have to assess its particular epidemiologic situation.

In recent years economic factors in many countries have led young adults to migrate from rural to urban areas. Persons who have recently migrated from rural areas with low population densities and who are thus less likely to have been previously exposed to measles may be at relatively increased risk for infection. When these persons congregate in crowded settings that favor measles virus transmission, they are at increased risk for acquiring measles should the virus be introduced.

Certain institutional settings such as colleges and universities, military barracks, health care facilities, large factories, and prisons can facilitate measles transmission if measles virus is introduced. Indeed, many measles outbreaks among adolescents and young adults have been documented in these settings, even in institutions with very high measles vaccination coverage.

In addition to persons living or working in institutional settings, adolescents and young adults who travel to countries with endemic measles transmission are at increased risk of being exposed to the virus. To prevent the occurrence of measles outbreaks among adolescents and adults, efforts need to be made to assure measles immunity in persons potentially at "high risk" for being exposed to the measles virus.

### 5.6 Vaccination Week in the Americas

First held in 2003, the Vaccination Week in the Americas (VWA) is an instrument for intensifying the Expanded Program on Immunization (EPI) through regionally coor-

dinated vaccination campaigns. Its underlying principles are equity, access, and Pan-Americanism. The main goals of VWA are to reach traditionally excluded populations, to revitalize transborder efforts, to strengthen the primary care network, and to make vaccination a priority on the political agenda in all countries of the Region.

Forty-two countries and territories participated in 2004 in VWA. In total, 41.8 million children and adults were vaccinated against poliomyelitis, measles, rubella and congenital rubella syndrome, pertussis, tetanus, diphtheria, tuberculosis, and/or influenza. Furthermore, many countries took advantage of the campaign to include other interventions, such as eye examinations to detect retinoblastoma, administration of folic acid supplements to women and vitamin A to children, and distribution of packets of oral rehydration solution. Intense coordination across borders resulted in more than 22 binational campaigns.

Generally countries took one of two approaches to participating in the 2004 VWA. Those countries which had already programmed activities for 2004 (such as measles follow-up campaigns, additional doses of polio vaccine, accelerated rubella and CRS control, and vaccination of the elderly) carried them out during the period scheduled for the VWA. The remaining countries intensified vaccination activities targeting children aged 4 years or less and women of childbearing age. Where countrywide efforts were not possible, at-risk areas and groups were prioritized by targeting municipalities with low coverage, marginal urban areas (especially those with periurban slums), border areas with high levels of population exchange or other risk factors, and indigenous groups. Impact of the VWA was measured by assessing the achievement of national goals, through preset performance indicators and surveys (such as coverage surveys and surveys on local awareness about the VWA).

## 6. INTEGRATED MEASLES/RUBELLA SURVEILLANCE

A sensitive surveillance system is essential to monitor progress toward and to sustain measles elimination. In the initial stages of measles elimination efforts, the primary purpose of measles surveillance is to detect in a timely manner **all areas** where the measles virus is circulating, not necessarily to investigate every suspected measles case. However, once endemic transmission has become rare or has been interrupted, the surveillance goal becomes to detect and investigate all suspected measles cases, including those imported, and to implement activities that prevent or limit secondary transmission. This goal requires rapid notification and investigation of all suspected measles patients. A surveillance system must be maintained even after endemic measles virus transmission has been interrupted. Besides the rapid detection of imported cases, a surveillance system that has a satisfactory record over several years will be paramount for the eventual certification of measles elimination.

The three main components of a surveillance system are: (1) detection and notification of suspected cases; (2) investigation, including active case searches, timely collection of a blood sample, and laboratory workup; and (3) final classification. Since illnesses characterized by fever and rash are widespread and have many different causes, clinical suspicion of measles cannot confirm a case. Laboratory investigation for measles-specific immunoglobulin M antibodies (IgM) in sera of suspected measles cases is important to confirm or exclude a measles virus infection. Likewise, specimens for viral isolation are important to determine the viral genotype responsible for an infection. To be discarded, a suspected measles case must undergo an adequate epidemiological investigation and have a negative laboratory result for measles-specific IgM in a blood sample collected within an appropriate time frame (30 days from rash onset).

When case-based measles surveillance started in the early 1990s, rubella cases were also detected and the incidence of rubella in the Americas became apparent. Several countries initiated efforts to eliminate rubella, and this goal was endorsed regionally in 2003. Given the similarities in clinical presentation, epidemiologic investigation, and laboratory workup, surveillance for measles and rubella in the Americas should be fully integrated. Reporting and investigation of suspected cases of measles or rubella should thus follow the same channels and procedures. Except for outbreaks, all serum specimens of suspected cases should be tested for both measles- and rubella-specific IgM.

Before discussing practical aspects, key concepts need to be defined. Adherence to these definitions will guarantee that surveillance efforts and outcomes are comparable among countries.

## 6.1 Definitions

A **suspected case** is a patient in whom a health care worker suspects measles or rubella infection **or** a patient with fever and rash.

Upon investigation, all suspected cases should be classified into one of three mutually exclusive categories:

- A **laboratory-confirmed case** is a suspected case which has laboratory results indicating infection with a measles/rubella virus **and/or** was epidemiologically linked to a case with such laboratory results.
- A **clinically confirmed case** is a suspected case which has not been adequately investigated.
- A **discarded** case is a suspected case which, upon adequate investigation that includes a blood specimen collected in the appropriate time frame, lacks serologic evidence of a measles/rubella virus infection.

Based on the infection source, confirmed cases should further be classified into one of three mutually exclusive categories:

- An **imported measles case** is a confirmed case which, as supported by epidemiological and/or virologic evidence, was exposed outside of the Western Hemisphere during the 7–21 days prior to rash onset. For **rubella**, the time frame is 12–23 days.
- An **import-related case** is a confirmed case which, as supported by epidemiological and/or virologic evidence, was exposed locally as part of a transmission chain initiated with an imported case.
- A **case with unknown source of infection** is a confirmed case for which the source of infection was not identified.

Classification of confirmed cases by infection source is critical to evaluate whether endemic circulation of measles/rubella virus has been reestablished in a country. In particular, **reestablishment of endemic transmission** is a situation in which a chain of transmission continues uninterrupted for a period > 12 months.

Ultimately, surveillance is meant to provide evidence that the measles and rubella viruses have been eliminated in the Americas. With this regard, **measles elimination in the Americas** is the interruption of endemic measles virus transmission in all countries. **Elimination of rubella and CRS in the Americas** is the interruption of endemic rubella virus transmission in all countries and the absence of CRS cases due to endemic virus transmission.

### 6.2 Identification and Notification of Suspected Cases

Consistent identification and notification of suspected cases is the backbone of a surveillance system, and relies on health care workers. Every health care worker should not only be familiar with the clinical presentation of measles and rubella, but with what action is required when faced with a patient suspected of measles/rubella. Health workers have three main responsibilities: to identify suspected measles/rubella cases, to secure specimens for laboratory testing, and to notify health authorities about the suspected case. In some instances, health officials may ask clinical personnel to carry out the investigation (see Section 6.3).

**Identification.** As defined in the previous section, a patient in whom a health care provider suspects measles or rubella virus infection **or** a patient with fever and rash is, for surveillance purposes, considered to be a **suspected measles/rubella case**. Clinical personnel need to be aware that, in contrast to their daily tasks, they are not asked to make a diagnosis, but simply to suspect the occurrence of measles/rubella. The definition of suspected cases is meant to be broad and sensitive. Whenever a measles

virus infection is suspected, actions to curtail transmission need to be taken well before confirmation can be made.

As measles has become very rare in the Americas, clinicians may have become less likely to include measles among the differential diagnoses of febrile, eruptive illnesses. Also, younger health care workers are unfamiliar with measles/rubella presentation. Yet, symptoms and signs of measles and rubella are regularly encountered. A rash is the symptom common to both measles and rubella patients. It is maculopapular, i.e., it contains both macules and papules. Macules are circumscribed areas of change in normal skin color, with no skin elevation or depression; they may be of any size. Papules are solid, raised lesions up to 0.5 cm in diameter. Whereas fever can be as high as 40.6°C (105°F) in measles patients, it is low grade in rubella patients. Fever in children with rubella is often absent. In addition to rash and fever, measles patients typically present with cough, runny nose (coryza), and/or pink eyes (conjunctivitis). These symptoms are not generally present in rubella patients, who often have lymphoadenopathy instead. Up to 50% of rubella infections are subclinical or inapparent.

Differences in clinical presentation make it difficult to find a definition of a suspected case that is both sensitive and specific to both measles and rubella. In particular, the definition for a suspected measles case recommended by WHO (i.e., any patient with fever and a maculopapular rash and cough, coryza, or conjunctivitis) is not sensitive for rubella. While detection of patients with fever and rash is relatively unspecific, this approach is straightforward and should guarantee a very sensitive surveillance.

**Specimen collection.** Whenever measles/rubella is suspected, health care workers should secure specimens for laboratory confirmation. A blood sample should be collected on first contact with the patient. As the likelihood of detecting IgM antibodies decreases with time, blood specimens must be collected within 30 days of rash onset. Shipment of the sample to a recognized laboratory should take place as soon as possible. Preparation of the specimen for shipment is discussed in detail in Chapter 7.

Data on viral genotypes are critical for tracking transmission pathways, investigating suspected vaccine-related suspected cases, documenting the elimination of endemic strains, and supporting the hypothesis of importations from other Regions. Therefore, specimens for viral detection and isolation should also be collected on first contact with the patient. Aspirates, throat swabs, or nasopharyngeal swabs are the preferred sample for viral detection/isolation for both measles and rubella viruses, but urine samples are an acceptable alternative. Collection of both types of samples increases the likelihood of viral detection/isolation. Shipment to a recognized laboratory can be delayed until serological results are known. Details on collection, storage, and shipment of specimens for viral detection/isolation are described in Chapter 7.

**Notification.** Health care workers should immediately notify all suspected cases to local surveillance authorities. The channel of this notification and the information included depends on local conditions, but needs to be simple and efficient. A form that can be used within the framework of an integrated measles/rubella surveillance system is shown in Annex 3.

While identification and notification rely heavily on the motivation and knowledge of clinical personnel, health officials are responsible for ensuring that health care workers know how to identify and notify suspected cases, to establish a surveillance network, and to maintain a surveillance of adequate quality.

All health care workers—physicians, nurses, allied health personnel, or record clerks—should know how to identify and notify suspected cases. Program surveillance officers should regularly organize training workshops, attend association meetings, and, if possible, visit health facilities in person. Visual aids, such as flipcharts, should be used in the training sessions, and simple written material describing suspected cases and responsibilities should be distributed.

The surveillance system can be based on a network of selected sites that can be monitored closely. The choice of sites depends on local conditions and should attempt to maximize both the likelihood and timeliness of identifying a suspected case. At least one site—either a health unit or hospital (both inpatient and outpatient clinics)—should be chosen in each municipality. As they may be the first to see a suspected patient, private hospitals and practitioners need to be included as well.

Program surveillance officers should visit sites on a regular and frequent basis to establish and monitor the reporting system. Training and close ongoing supervision are important, as staff turnover may be frequent in many areas. Specific information on what and how to report should be given. Sites should report all suspected cases immediately. However, if no suspected cases are identified, sites should still send a report once a week, the so-called "zero-case reporting" or negative reporting. While one should be careful not to overload clinical personnel with surveillance tasks, site visits can be a good occasion to disseminate information on other reportable diseases or conditions. Annex 4 shows a form that could be used to report suspected cases of measles, acute flaccid paralysis, and other vaccine-preventable diseases. To guarantee sustainability of the surveillance network, only a minimum of data should be requested. Considerations specific to different types of sites and health care workers are discussed in the following sections.

**Health facilities** (see Box 5). Every health facility should designate one individual and alternates who are responsible for keeping track of suspected measles cases and immediately reporting all new suspected measles cases. Reports should be submitted to local and/or state surveillance coordinators according to how the surveillance system is organized. A special "hot line" should be established to transmit this infor-

### Box 5. PROCEDURE FOR MEASLES/RUBELLA SURVEILLANCE IN A HEALTH CENTER

1. Attach a **Notification and Investigation Form to the medical chart** of all patients with fever and rash.
2. Health care workers should ask parents whether anyone else they know, for instance in their household or village/town, had fever and rash.
3. When a health care worker suspects measles or rubella, **the District Health Officer should be notified immediately**. The surveillance case definition for a "suspected measles/rubella case" is any patient of any age in whom a health care worker suspects measles/rubella infection or a patient with fever and rash.
4. For all suspected cases, a blood specimen should be collected immediately. **A copy of the Notification and Investigation Form should be sent with the acute blood**.
5. Plans should be made to visit the home of the patient and the surrounding area to find additional suspected cases.
6. Whenever suspected cases are identified, the doctor or nursing director should call the epidemiologist in charge of surveillance.
7. On a specific day of the week (e.g., each Tuesday), the **Weekly Surveillance Report** summarizing the number of suspected cases seen in the previous week, even if no case was seen, should be telephoned, faxed, or sent by messenger to the epidemiologist. If applicable, a copy of the Notification and Investigation Form should be included.

mation by the fastest means possible (aerogram, telegram, telephone, fax, e-mail, etc.). State, regional, and provincial officials should, in turn, transmit weekly to the national level the reports they receive from the health facilities in their jurisdictions, and national authorities should report weekly to coordinating agencies.

**Hospitals.** Case-finding through the emergency department and pediatrics ward is critical to the success of a measles surveillance system. A doctor or nurse should be assigned at each hospital to check pediatric and infectious disease wards visually and to review admission records for suspected measles cases.

**Private practitioners.** As already mentioned, private medical practitioners should be included in the surveillance system, as they may be the first to see suspected measles cases. In some areas, sentinel reporting systems can be set up among community pediatricians. Involvement of practitioners is more likely to succeed if training is offered, contacts are frequent, and feedback is regular. An example of correspondence with a private practitioner is shown in Annex 5.

**Community sources.** In addition to all health facilities, a network of community reporters should be organized to report suspected measles cases. Community involvement is critical when cases are sporadic, as is now the case with measles in the Americas. These reporters might include pharmacists, private practitioners, health workers at private clinics, village leaders, school personnel, and anyone else likely to learn of or have contact with sick children.

**Laboratory reporting.** Every effort must be made to ensure that laboratory, epidemiologic, and operational personnel work closely together. It is important to establish routine communications with all local laboratories that may receive serum specimens for diagnosis of suspected measles cases. Laboratory personnel should be instructed to notify the surveillance coordinator immediately when specimens are labeled measles, rubella, or another febrile, eruptive illness. In any local laboratory, the log book should be checked once each week to ensure that all suspected cases are being reported promptly (see Annex 6).

**Active case-searches.** To ensure that all suspected cases are identified and notified, periodic active case-searches should be conducted. These are particularly important in areas that do not notify cases (i.e., "silent" areas) and high-risk areas. They are mainly conducted in health facilities (clinics and hospitals), but can also be performed in institutions, schools, and in the community. In health facilities, registration records, discharge diagnoses, and hospital charts are reviewed to identify patients with fever and rash illnesses, such as dengue and scarlet fever. If potential cases are spotted, medical records should be reviewed carefully and/or the physician or nurse who provided care to the individual should be interviewed to determine whether the patient met the criteria of a suspected measles/rubella case. If that was the case, it must then be determined if it was reported and was the object of an adequate investigation. In institutions such as penitentiaries and mental health facilities one would do the same by reviewing, for instance, infirmary logs. In the community and in schools, active case-searches are conducted by asking people if they know or have recently seen anyone with a febrile, eruptive illness. This activity can be aided by using pictures of a patient with maculopapular rash.

### 6.3 Investigation

Upon notification, investigation of suspected cases should start immediately. Epidemiologists or other specially trained staff should be in charge of the investigation. The three main elements of an **adequate investigation** are: home visit within 48 hours of notification; completeness of relevant data (i.e. date of rash onset, date of notification, date of investigation, date sample taken, type of rash, presence of fever, dates of previous measles/rubella vaccinations); and active case-searches.

A **unique case identification number** should be given to each suspected case. This case number should begin with one or more three-letter combinations to designate the geographic location, followed by the year and the case number. For example, the unique identifier "MEX–JAL–97–001" refers to case number one of 1997 for the state of Jalisco in Mexico. All communications and forms related to the case should cite the unique case identification number.

The following, practical steps are usually taken as part of the investigation (see also Box 6):

- Complete the form for the notification and investigation of suspected measles/rubella cases (see Annex 3).
- Update the line-listing of suspected cases (see Annex 7).
- Visit the home of the reported suspected case to obtain basic demographic and clinical information. Establish the time for a follow-up visit at the patient's home to evaluate the family/friends for evidence of illness and to provide immunizations as needed (see Annex 8).
- Collect blood specimens and specimens for viral isolation from suspected measles cases.
- Inform surveillance sites and surveillance coordinators in nearby areas that a suspected case has been identified. If the case is located close to a national border, the neighboring country should be informed.
- Conduct contact tracing to identify the source of infection and determine whether other areas have been exposed or are also experiencing outbreaks. Identify all people the suspected patient had contact with during the time he/she was contagious; make a line-listing of these contacts (see Annex 7), including their names and addresses, and determine whether they are or were ill. Follow-up will be needed to determine if a contact subsequently became ill. If so, laboratory specimens must be collected.
- Evaluate vaccination coverage levels and provide measles vaccination to unvaccinated persons (see Chapter 8, "Response to Measles Outbreak").
- Search actively for other suspected cases in the neighborhood, at school/work, areas of frequent travel, etc., of the reported suspected case by using the "rapid coverage monitoring" method.

Investigators must make sure that **specimens for laboratory confirmation** are collected and analyzed rapidly. First, investigators need to check whether blood specimens and specimens for viral isolation have been collected from suspected patients. If not, they must arrange collection of those specimens as soon as possible. Blood specimens must be collected within 30 days of rash onset. Once collected, they must be shipped to an official laboratory as soon as possible; blood specimens must arrive at the laboratory within five days of collection. If specimens for viral isolation are not shipped along with the blood specimen, adequate storage of these specimens must be verified. Once a case has been confirmed at the laboratory and an outbreak is occurring, it is not necessary to collect specimens from every suspected case (see Chapter 8, "Response to Measles Outbreak").

## Box 6. IMPORTANT CONSIDERATIONS FOR THE INVESTIGATION OF SUSPECTED MEASLES/RUBELLA CASES

**NOTE:** During the first contact, the health care worker must make every effort to obtain basic information, epidemiologic and clinical data, and a blood sample, as it may be the only contact with the patient.

1. As soon as a health care worker suspects measles or rubella infection, the patient or his/her parents should be informed that a public health official will be visiting their home. Explain about the measles/rubella elimination program, and why a visit is necessary.
2. Arrange for a time to visit the family when all family members are expected to be at home; this may mean an evening visit.
3. On the field visit, take case notification and investigation forms and measles/rubella vaccine. Only suspected cases should have blood drawn.
4. Ask about additional suspected cases in the home, adjacent homes, or in the neighborhood. Remember that some cases may be in either the incubation period or early stages of the illness, with only a fever and flu-like symptoms. It is important that the families know whom to contact if a rash should occur. In addition, a visit/call should be made every two days for a period of three weeks to ask if any new suspected cases have occurred in the household.
5. All families should be advised to keep the patient at home and to allow only indispensable visitors until the rash disappears.
6. Ask the family if they know when/where the patient got the illness. It will be necessary to explain the incubation period to them, and that after exposure occurs it takes about 10–14 days for symptoms to start. Remember that the case may have been exposed to someone who did not have a rash. This is important, as measles/rubella is highly contagious even before the rash appears.
7. Visit adjacent homes (for example, within a radius of 100 to 1,000 yards around the case or in the same block or neighborhood) and ask, in person, whether any case of fever and rash has occurred during the previous month. Also check the immunization status of all children aged 15 years or less living in the households.
8. Investigate any reports either of rash illness or general flu-like illness. It may be necessary to visit clinics, homes, or other possible places of exposure to see if there has been a rash illness and to fully investigate the case.
9. In addition, preschools, nurseries, schools, church groups, etc., in the area should be visited to find out if any fever and rash illnesses have been occurring.
10. Vaccinate or revaccinate household members and any neighbors, playmates, or schoolmates who have been exposed directly to the case-patient during his/her illness. This usually includes children aged between 9 months and 14 years. Take vaccination consent forms so that, if necessary, teachers can pass them on to the parents for permission to vaccinate.
11. Send out pamphlets or notify by word of mouth the neighborhood, preschools and schools, and local leaders that there is a suspected case in the area, and that anyone aged between 9 months and 14 years who has not been vaccinated needs to be vaccinated as soon as possible.
12. Call local private medical doctors to inform them about the suspected measles/rubella outbreak and about the mandatory notification of any suspected patient, and to ask if they have seen any cases of fever and rash illness.

One goal of the investigation is to find who might have infected the patient under investigation. Specifically, where there is suspicion of measles, one looks for someone with whom the reported suspected patient had contact 7 to 21 days before the suspected case developed the rash and who had an illness with fever and rash at that time. In other words, inquiries should be made to determine whether suspected cases occurred or are occurring in places that the patient under investigation visited between 7 and 21 days prior to his/her rash onset, such as a preschool center, school, or another town or village. When rubella is suspected, the time frame of interest is 12 to 23 days prior to rash onset in the suspected patient.

During outbreaks, if there are more than 10 suspected cases in each single area, the household visits should be reduced or eliminated, depending upon the availability of investigators. However, the Suspected Case Line-listing should be filled out for each suspected case and particular attention paid to obtaining basic demographic data, including the age and vaccine history of the patient.

Recent outbreaks in the Americas have shown that when measles is rare, active case-searches are critical to finding suspected cases. Active case-searches should be carried out in health facilities and other sites as explained in the previous section. At the community level, at least one survey based on the "rapid coverage monitoring" methodology should be conducted in the neighborhood where the patient resided when he/she was contagious (four days before rash onset to four days after rash onset).

In addition, the public should be kept well informed and community leaders should be asked to assist in case finding. Health staff in the affected and nearby areas should use every contact with patients as an opportunity to inquire about rash and fever illnesses. Efforts to identify additional cases should extend well beyond the neighborhood community in which the suspected case lives. Case finding activities may include visiting blocks adjacent to the affected household, sending notices to health care providers asking if they have seen or heard of persons with fever and rash illnesses, and visiting local health centers, hospitals, and clinics to review medical records.

If detected, notified, and investigated in a timely manner, a suspected case should be investigated during a time frame when the patient is potentially contagious. A patient with measles is contagious from four days before to four days after rash onset; a patient with rubella is contagious from seven days before to seven days after rash onset. As part of the investigation, measures need to be taken to prevent and track the spread of the infection, specifically isolation and monitoring of contacts. Only vaccinated persons should be allowed to investigate suspected measles/rubella cases.

**Isolation.** Suspected cases should not leave their residence until five days after rash onset (eight days if rubella is suspected). During this period of patient isolation, contact should not be permitted with susceptible family members (e.g., infants and unvaccinated adults) and only vaccinated people should be allowed to visit the

household. Because of the high risk of intra-hospital transmission, suspected cases should not be hospitalized unless absolutely necessary.

Important precautions need to be taken in health facilities. As a principle, all health care workers must be immune to measles and rubella. Whenever **measles** is suspected, precautions against airborne pathogens should be taken in addition to standard precautions (e.g., washing hands, wearing gloves when in contact with body fluids, using gowns). The patient should be isolated in a room that has negative air pressure in relation to other part of the facilities and an appropriate discharge of air to the outdoors. If air is recirculated, monitored, high-efficiency filtration of room air before the air is circulated to other areas in the hospital should be in place. The room door must be kept closed, and no susceptible person should be allowed to enter the room. Only essential movement and transport of the patient from the room should be allowed; if necessary, the patient should wear a surgical mask. When **postnatal rubella** is suspected, droplet precautions should be taken. The patient should be isolated in a room. Precautions for patient movement are the same as for measles.

**Monitoring close contacts.** All close contacts of a suspected measles patient should be identified and monitored closely for four weeks from the day the patient under investigation developed rash (five weeks for rubella suspicion). Contacts are defined as all persons living in a household or other close quarters with the suspected patient when he/she was contagious (see above).

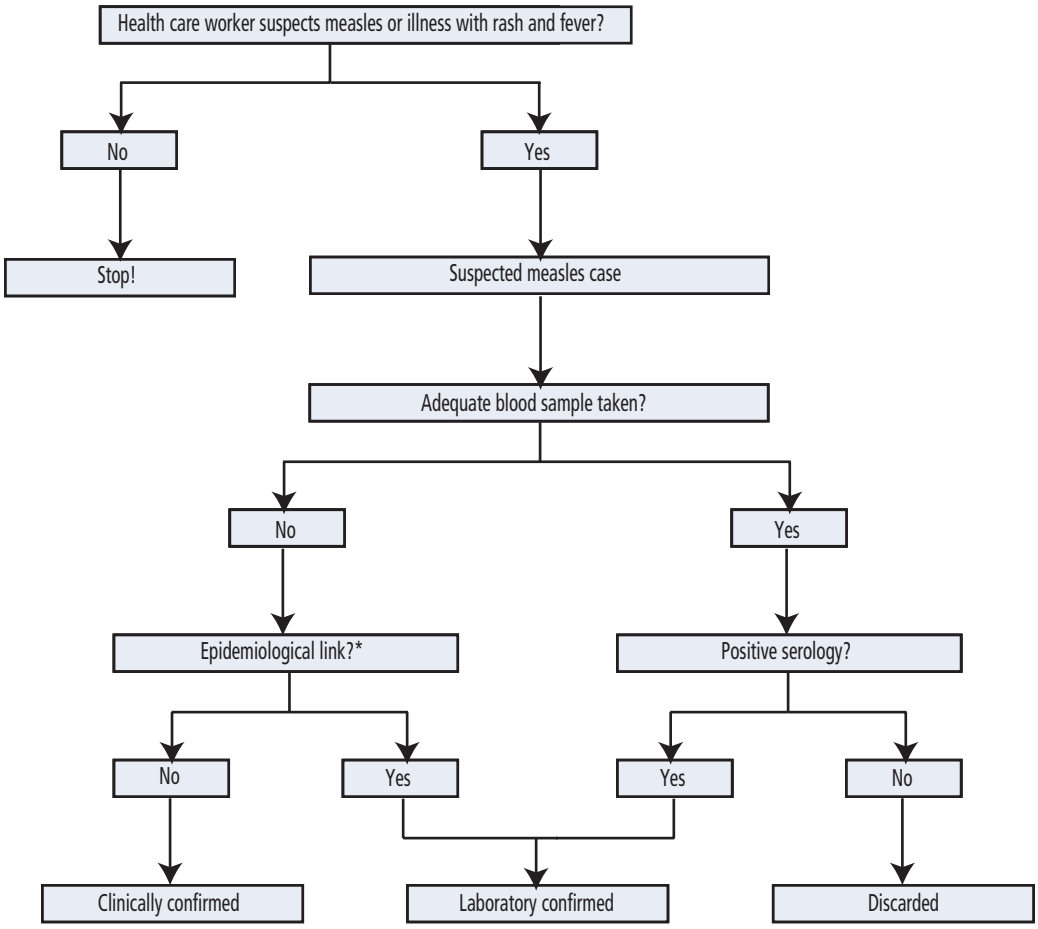
A line-listing should be made of all contacts with their names and addresses. Contacts should be asked about their vaccination status, clinical symptoms or signs that might suggest measles/rubella, and travel history. Contacts who have not received two doses of vaccine should be considered susceptible. Susceptible contacts should be vaccinated immediately, and investigators are urged to consider whether to isolate them and prevent them from attending school, work, or other large gatherings, such as church, clubs, and baby-sitting groups.

If less than five days have elapsed since the suspected case developed the rash (eight days for rubella suspected patients), all contacts should receive the isolation instructions whether or not they have been immunized. Contacts should be instructed about the prodromal symptoms, to stay home if such symptoms developed during the four week monitoring period (five weeks, in the case of rubella), and to contact health authorities.

### 6.4 Case Classification

As defined in Section 6.1, upon investigation, all suspected cases should be classified into one of three mutually exclusive categories, i.e., laboratory-confirmed cases, clinically confirmed cases, or discarded cases (Figure 13).

**Figure 13. Classification algorithm of suspected measles cases**




* The suspected case is epidemiologically linked to a laboratory-confirmed case.

**Laboratory-confirmed cases.** A laboratory-confirmed case is a suspected case which has laboratory results indicating a measles/rubella virus infection and/or was epidemiologically linked to a case with such laboratory results.

Laboratory results that confirm a measles/rubella virus infection are:

- Detection of measles or rubella specific IgM in a blood specimen of a suspected case;
- Isolation of measles/rubella virus in a specimen of a suspected case; **or**
- Confirmation by a reference laboratory using other standard laboratory techniques.

Chapter 7 discusses in detail the laboratory confirmation of measles virus infection, in particular, specimen collection and shipment, as well as laboratory methods and interpretation of their results.

Other suspected cases can be empirically considered to be laboratory-confirmed if they are epidemiologically linked to another laboratory-confirmed measles/rubella case. For measles, an epidemiologic link is defined as a direct contact with another laboratory-confirmed case whose rash onset was 7–21 days before that of the case under investigation. For rubella, the time frame is 12–23 days before rash onset in the suspected case.

**Clinically confirmed cases.** A clinically confirmed case is a suspected case which—for any reason—has not been adequately investigated. Since measles/rubella virus infection was suspected by a health care provider and the possibility of measles/rubella virus infection could not be excluded, these cases cannot be discarded. Cases may be classified in this category because the patient died before the investigation was complete, the patient could not be located or was lost to follow-up, or the patient received only a clinical diagnosis from a health care provider without laboratory investigation.

When an epidemiologic investigation is not conducted and measles/rubella virus infection can neither be confirmed nor excluded, these cases are considered to be failures of the surveillance system. In an elimination program, the goal of the measles surveillance system is to conduct a complete epidemiologic investigation of **every** reported suspected case and to have as few clinically confirmed measles/rubella cases as possible. Of the total confirmed cases, at least 95% should have laboratory confirmation of measles/rubella infection (see Section 6.6, "Monitoring Surveillance Quality").

**Discarded cases (not measles/rubella).** A discarded case is a suspected case which, upon adequate investigation that included a blood specimen collected within the appropriate time frame, lacks serologic evidence of measles/rubella virus infection. Although a single negative serologic result on a blood specimen taken within 30 days of rash onset is sufficient to discard a case, laboratory evidence of another infection commonly associated with fever and rash, such as dengue, further supports discarding a suspected case.

The office responsible at the national level for the surveillance system should receive a copy of all Notification and Investigation Forms and should periodically review the distribution of case classifications. In particular, symptoms and initial clinical diagnosis of discarded cases need to be reviewed (see Annex 9).

Confirmed cases should be further classified according to the source of the infection as imported cases, import-related cases, or cases with an unknown source.

**Imported cases.** An imported measles case is a confirmed case which, as supported by epidemiological and/or virologic evidence, was exposed outside the Western Hemisphere during the 7–21 days prior to rash onset. For rubella, the time frame is 12–23 days. A travel history to an area where measles occurs and during a plausible

time frame must be demonstrated; results of molecular sequencing of the virus isolated from the cases should be compatible with the areas/countries visited. The possibility of local exposure to measles must be excluded after a careful community investigation.

**Import-related cases.** An import-related case is a confirmed case which, as supported by epidemiologic and/or virologic evidence, was exposed locally as part of a transmission chain initiated with an imported case. A chain of transmission is two or more confirmed cases that are linked epidemiologically. The investigation should thus demonstrate that the import-related case had direct contact with an imported case (or another import-related case) whose rash onset was 7–21 days before that of the case under investigation (12–23 days before rash onset for rubella). Molecular sequencing data of the isolated virus, if available, could support the link.

**Cases with unknown source of infection.** A case with an unknown source of infection is a confirmed case for which the source of infection was not identified. It is possible that an epidemiological link to an imported case or an import-related case cannot be found even after a thorough investigation, and sporadic cases with unknown source of infection are not necessarily indicative of endemic transmission. The pattern of occurrence of these cases (e.g., number of transmission chains and number of cases involved, geographical and temporal distribution) is as important as their number.

### 6.5 Practical Dilemmas in Case Classification: Vaccine-related Cases and Cases with False-positive Laboratory Results

When no measles case has been confirmed for years, the occurrence of an IgM-positive result causes great concern to national health authorities. Health officials often question the accuracy of such results. In principle, as long as there is no evidence to the contrary, all suspected cases that have an IgM-positive result should be considered laboratory-confirmed cases, and adequate investigation and control measures need to be initiated immediately. In a country with no known transmission, the finding of sporadic measles cases with little or no secondary transmission does not imply a resurgence of endemic measles transmission. In the recent examples of the United States, Canada, and Mexico, the finding of sporadic cases demonstrated that surveillance was sufficiently sensitive and that local vaccination coverage levels were adequate to prevent an outbreak.

However, two situations exist in which an IgM-positive result is not associated with a case having a wild-type measles virus. First, a patient who was recently vaccinated with measles- or rubella-containing vaccines may develop rash (up to 5% of individuals after measles vaccination), would ideally be reported as a suspected case, and usually would have an IgM-positive result. Second, the specificity of the

kits for the detection of measles/rubella-specific IgM (ability to rule out a measles/rubella virus infection) is not 100%. Some patients with eruptive illness, such as dengue or erythema infectiosum, may test positive for measles- or rubella-specific IgM. Establishing whether either situation occurred is time-consuming. As stated before, all suspected cases with an IgM-positive result should be considered laboratory-confirmed, and control measures need to be initiated immediately.

**Vaccine-related cases.** In addition to laboratory results, criteria to classify a case as vaccine-related should include clinical presentation, time between vaccination and illness onset, time between illness onset and sample collection, and epidemiological information. Specifically, a suspected measles case can be classified as discarded and diagnosed as a vaccine-related rash if it meets **all five** of the following criteria:

- The patient had a rash illness, with or without fever, but did not have cough or other respiratory symptoms related to the rash;
- The rash began 7–14 days after vaccination with a measles-containing vaccine;
- The blood specimen, which was IgM-positive, was collected 8–56 days after vaccination;
- A thorough field investigation did not identify an index case or any secondary cases; and
- Field and laboratory investigation failed to identify other causes (including the inability to identify wild-type measles virus in culture).

Countries should ensure that suspected cases meet the above criteria prior to discarding them and diagnosing them as a vaccine-related illness. Those criteria will lead to confirmation of a few suspected cases whose illness actually was vaccine-related, but this misclassification is an acceptable compromise to ensure the highest sensitivity in measles surveillance.

**Cases with false-positive results.** While an accurate investigation often allows confirmation as to whether a vaccine-related case occurred, evaluation of a potential false-positive result is complex and a conclusive answer usually depends on the extent to which tests for other causal agents were carried out. In principle, failure to establish an alternate diagnosis through laboratory testing implies that the suspected case must be confirmed as measles or rubella. With the exception of pregnant women in rubella outbreaks, false-positive results are really only an issue for sporadic cases.

Each result thought to be false-positive needs to be considered on a case-by-case basis taking into account clinical presentation, vaccination history, epidemiological

data, and laboratory results. In terms of laboratory investigation, follow-up of IgM results thought to be false-positive should include repeating the IgM test with the same EIA to measure IgG titer levels in paired sera (first sample collected within seven days of rash onset, second sample two to three weeks thereafter). When possible, viral detection/isolation and avidity assays (rubella only) should be done.

To discard a suspected case with an IgM-positive result (but with no relation to vaccination), laboratory results must confirm a diagnosis other than measles/rubella that is compatible with the clinical presentation of the suspected patient. In addition, a thorough field investigation must have been conducted and failed to identify any measles/rubella cases (whether an index case or secondary cases). A suspected case should never be discarded merely on the basis of a clinical presentation that is not viewed as typical for measles/rubella.

### 6.6 Monitoring Surveillance Quality

To assure a high-quality surveillance, the surveillance system must be monitored regularly and systematically, using a set of formal indicators. Regular feedback to everyone involved in the surveillance system is important to assure sustainability and refinements to the system are implemented as necessary.

The number of units reporting and the timeliness of the reports should be monitored weekly. To evaluate the weekly reporting system (particularly in areas with all negative reports), interviews should be conducted with personnel involved in surveillance at all administrative levels.

The following indicators are used to monitor the quality of measles surveillance (see Annex 10):

**Proportion of reporting sites that report weekly.** At least 80% of surveillance sites should report each week on the presence **or** absence of suspected cases. In the calculation of this proportion, the numerator is the number of sites for which a report was received for the week under consideration, and the denominator is the total number of sites within the surveillance system.

**Proportion of suspected cases with adequate investigation.** At least 80% of all suspected cases should have had an adequate investigation. In the calculation of this proportion, the numerator is the number of suspected cases for which an adequate investigation was carried out, and the denominator is the total number of suspected cases. An adequate investigation includes, at minimum: home visit within 48 hours of notification (clinical and epidemiologic investigation of the suspected case as well as of contacts of the suspected case); completeness of relevant data (i.e., date of notification, date of investigation, date of rash onset, date sample taken, type of rash, presence of fever, dates of previous measles/rubella vaccinations); and active case-searches.

**Proportion of suspected cases with a blood specimen collected within 30 days of rash onset or epidemiologic link to a laboratory-confirmed case.** At least 80% of suspected cases must have a blood specimen collected within 30 days of rash onset or be linked epidemiologically to a laboratory-confirmed case. In the calculation of this proportion, the numerator is the number of suspected cases with a blood specimen taken within 30 days (≤ 30 days) of rash onset or suspected cases which are epidemiologically linked to a laboratory-confirmed case, and the denominator is the total number of suspected cases. Blood specimens must be accompanied by the following basic information: case identification number, county/municipality, patient name, age, number of vaccine doses received, date of last measles/rubella vaccination, date of rash onset, date of notification, date of investigation, date of blood specimen collection, and case classification.

**Proportion of suspected cases with a blood specimen received at the laboratory within five days of collection.** At least 80% of all laboratory specimens collected from suspected cases must arrive at the laboratory within five days of collection. In the calculation of this proportion, the numerator is the number of suspected cases with a blood specimen received at the laboratory within five days (≤ five days) of collection, and the denominator is the total number of suspected cases with a blood specimen collected.

**Proportion of suspected cases with a blood specimen processed within four days of laboratory reception.** At least 80% of specimens must be tested and the results reported back to the surveillance unit within four days of specimen reception at the laboratory. In the calculation of this proportion, the numerator is the number of suspected cases with a blood specimen tested and results reported back to the surveillance unit within four days (≤ four days) of laboratory reception, and the denominator is the total number of suspected cases with a blood specimen received at the laboratory.

**Proportion of suspected cases that were laboratory discarded.** At least 95% of all suspected cases should be discarded because of serological results ruling out measles/rubella or ruling in another cause. In the calculation of this proportion, the numerator is the number of suspected cases that had negative serological results for measles and rubella or positive results for another cause, and the denominator is the total number of suspected cases discarded for any reason.

**Proportion of chains of transmission with representative samples for viral isolation.** At least 90% of transmission chains (two or more confirmed cases that are linked epidemiologically) should have representative samples for viral isolation. To ensure at least one isolate, samples from the first five to ten cases of a transmission chain should be collected; if the transmission chain continues over a period of time,

further cases should be sampled at intervals of two to three months and when the outbreak is ending. In the calculation of this proportion, the numerator is the number of transmission chains with representative samples for viral isolation, and the denominator is the total number of transmission chains.

The national surveillance team should also monitor other indicators, such as the proportion of sites/municipalities reporting at least one suspected case per year and the proportion of suspected cases identified with active case-searches which had already been notified. Surveillance managers should use the latter proportion as a means of evaluating the sensitivity of the surveillance system. It is expected that almost all suspected cases encountered in active case-searches will have been detected and notified prior to the active case-search.

While all are important, **three indicators are critical:** the proportion of suspected cases with adequate investigation, the proportion of suspected cases with a blood specimen collected within 30 days of rash onset or an epidemiologic link to a laboratory-confirmed case, and the proportion of transmission chains with representative samples for viral isolation.

Feedback includes providing surveillance participants with the following: (1) the number and location of reported cases, (2) an assessment of the level of promptness and accuracy of their surveillance reports, (3) information on the effectiveness of vaccination and control activities, (4) specific recommendations on how to solve common problems, and (5) commendations for personnel doing excellent work. Feedback can be provided effectively by sending weekly measles surveillance bulletins to the reporting sites and to interested parties (see Annex 11).

### 6.7 Information Systems and Analysis

An important aspect of a successful measles elimination program is a well-developed and decentralized information system that provides program managers and health workers with the information they need for taking appropriate actions. Information from the surveillance system is used to produce regular summary reports, which are distributed to the personnel responsible for taking actions on identified problems. All surveillance information should be standardized.

**Data collection.** Whether or not the information system is computer-based, it should cover case tracking and site reporting. At the state and district levels there should be a system that is capable of tracking all reported suspected cases until they are either confirmed or discarded (**case tracking**). Such a system is characterized by several important elements: unique case identification number; standardized form for notification and investigation; basic demographic data on each case; basic clinical data on each case; and recording and monitoring of laboratory specimens from collection to final laboratory results. At the central level, essential information, as

presented in the Suspected Case Line-listing, should be available for monitoring the basic surveillance indicators of the program.

At the national level and the subregional level, a system capable of keeping track of the reporting units should be in place (**site reporting,** Annex 12). Reporting units may be a geopolitical jurisdiction such as a county, district, or municipality, or a service unit such as a hospital, private clinic, or private practitioner. At a minimum, the submission of weekly reports, including negative reporting, and the timeliness of those reports (on time or late) should be regularly recorded for each unit.

**Data analysis.** Each geopolitical subdivision within a country should be part of the weekly reporting system and should report on measles/rubella occurrence and on the occurrence of other rash-like illnesses on a regular basis. Data from a region should be presented in a standardized format. At a minimum, it should include: monthly numbers of reported cases and case rates; laboratory results; final diagnoses of discarded cases; age distribution of confirmed cases; vaccination status of confirmed cases; geographic distribution (urban versus rural); and number of cases with a notification and investigation form.

Data from the notification and investigation form and line-listings should be analyzed to monitor reported suspected and confirmed cases by age, sex, location, and vaccination status as well as to determine whether standards for case reporting and investigation are being met.

**Age distribution:** Age distribution of cases permits health authorities to detect any changes in the epidemiology of the disease and to establish which age groups to target for vaccination.

**Geographic location:** Cases should be plotted on a map according to their place of residence, and the map compared with vaccination coverage data and sites reporting in the surveillance system. These maps can be useful for coordinating activities, such as setting up vaccination sites.

**Source of infection:** This information will help to identify areas where the measles/rubella virus is still actively circulating.

**Source of notification:** This information will help to determine whether improvements are needed regarding personnel notifying suspected cases. For example, if cases are being notified only from public health facilities, then additional contacts with private medical doctors and private clinics are required.

**Vaccination history of cases:** Accurate information on the vaccination history of confirmed cases is essential for evaluating vaccine effectiveness and detecting potential problems with the cold chain.

At the country level, a bulletin, preferably updated on a weekly basis, should be issued with results on suspected and confirmed cases. In addition, this bulletin should indicate the number of units reporting each week (including negative report-

ing). Information about the current epidemiology of acute flaccid paralysis, neonatal tetanus, and other EPI target diseases could also be included, and bulletins should be distributed to all health care providers and other interested health care personnel on a weekly or monthly basis.

# 7. LABORATORY CONFIRMATION OF MEASLES INFECTION

Since clinical diagnosis is not sufficient to confirm measles infection, the laboratory is critical in a measles elimination program. Measles infection can be confirmed by documenting a measles-specific immune response in the patient and/or by culture and isolation of the measles virus from a clinical specimen.

The most common technique used to confirm the diagnosis of measles is a test for the presence of measles-specific IgM antibodies in sera collected from suspected measles cases. For measles surveillance, a single blood specimen obtained shortly after rash onset may be sufficient to confirm or discard suspected measles cases.

Although technically more difficult than serologic assays, the culture, isolation, and genetic analysis of the measles virus obtained from measles outbreaks can provide important information about the circulation of measles virus. Therefore, appropriate clinical specimens for viral culture must be collected from every chain of measles transmission, as well as from any sporadic cases (see Section 7.2 on viral isolation).

In order to promote high-quality measles laboratory testing throughout the Region of the Americas, PAHO has established a regional network of measles laboratories. This network currently is comprised of 114 sub-national laboratories, 21 national laboratories, two regional reference laboratories, and one specialized reference laboratory. Each reference laboratory provides technical support and confirmatory measles testing for one or more national measles laboratories.

## 7.1 Measles Serology

Following primary infection with measles virus, measles-specific antibodies appear in the blood shortly after rash onset (Figures 14 and 15). IgM, IgG, and IgA antibodies are produced initially, but the detection of IgA antibodies is not used to confirm measles infection.

**Figure 14. Correlation of time of infection, incubation period, and communicability period following measles virus infection (in days)**

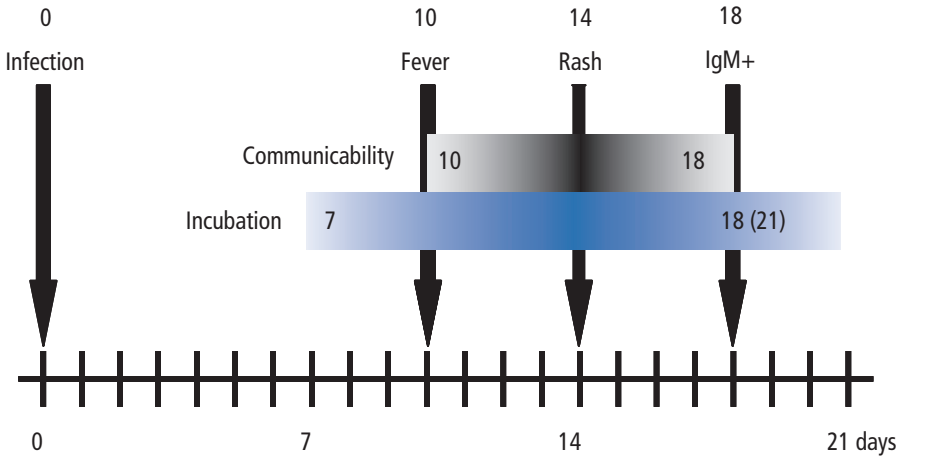
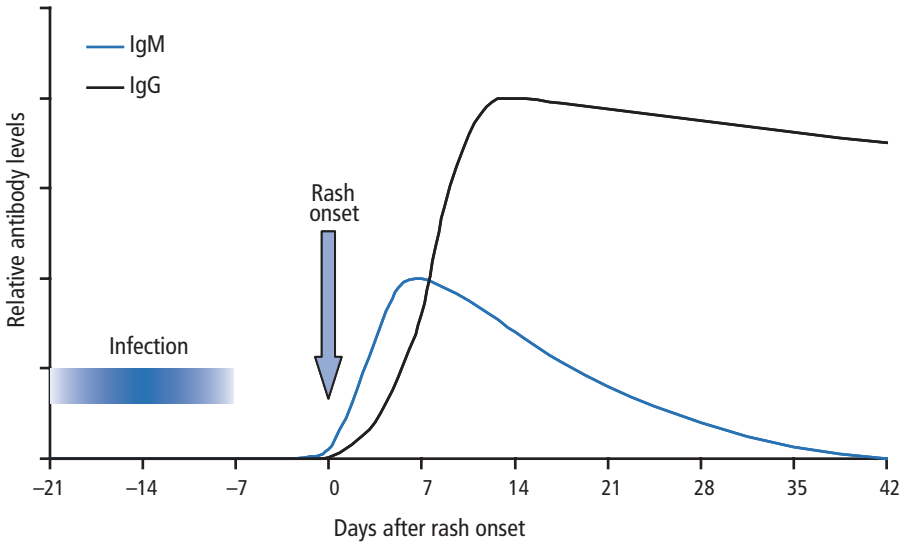


**Figure 15. Serological response to measles virus infection**




IgM antibodies appear first and can be detected shortly after rash onset. They attain peak levels approximately one week later, then gradually decline and are rarely detectable at six weeks after rash onset. The detection of measles IgM antibodies in the blood of a suspected measles case can be considered confirmation of measles virus infection. Some currently available serologic assays will not detect IgM in an immune individual following reexposure to measles virus.

IgG antibodies peak about two weeks following rash onset and are detectable for years after infection. Reexposure to measles virus in a person with preexisting measles immunity induces a characteristic anamnestic immunologic response, with a rapid boosting of IgG antibody levels.

At present, there is no single optimal serologic test for confirmation of measles virus infection—that is, a test that is both 100% sensitive and 100% specific, is quick, and can be easily performed in most basic laboratories.

Measles-specific IgM antibodies can be detected using both indirect measles IgM enzyme immunoassays (EIAs) and IgM capture assays. Indirect IgM EIAs are relatively easy to perform and require only two to three hours to complete. Whereas they have a fairly high sensitivity and specificity for measles-specific antibodies, false-positive results may be expected in periods of low measles incidence. IgM capture EIAs tend to have sensitivity and specificity over 97%; they will detect IgM antibodies in about 75% of measles cases on the first day after rash onset, and 100% by the third day after rash onset. IgM capture EIAs have produced excellent results in regional measles reference laboratories, but the tests' relative complexity and length (six to seven hours) have made it difficult to implement them in all state and national virology laboratories.

To counter the disadvantages of both types of assays and to allow a large number of laboratories throughout the Region to test for measles, the PAHO measles laboratory network has developed a two-step testing algorithm. First, sera from suspected measles cases are tested in state or national laboratories using an indirect IgM EIA. Second, all indeterminate samples and samples which are considered to be "problematic" by the indirect assay are sent to a regional measles reference laboratory for measles confirmation using IgM capture EIA. A "problematic" serum spec-

imen is usually one for which epidemiologic information suggests that the indirect assay result may be either false-negative or false-positive.

**Collection and shipment of sera.** In order to obtain sera from a high proportion of suspected measles cases, blood specimens should be collected at the suspected case's first contact with the health care system. While EIA tests for measles-specific IgM are more sensitive in sera taken between 4 and 30 days after rash onset, **a single serum sample obtained at the first contact of the suspected patient with the health care system, regardless of day following rash onset, is considered adequate for measles surveillance.** The serum sample should be sent to the state or national laboratory as soon as possible after collection. **Each blood specimen must be accompanied by a copy of the notification and investigation form.**

Staff responsible for the Expanded Program on Immunization (EPI) should train health workers in the proper and safe techniques of venous blood collection and ensure the availability of specimen collection kits that will be shipped to the laboratory.

Meetings with public health laboratory personnel are essential to establish clear procedures, at all levels of the health system, for the receipt and transport of any specimens that are submitted for measles serology. These procedures include ensuring that the proper forms accompany the specimen and that the person receiving the specimen signs a receipt.

*Collection and preparation of serology specimens:*

- Collect 5–10 ml blood (a minimum blood volume of 3 ml in infants and toddlers) by venipuncture into a sterile tube without coagulant, labeled with patient's name and/or unique identifier and collection date.
- If a centrifuge is available, centrifuge whole blood at 1000g for 10 minutes to separate serum. (Whole blood can be stored at 4–8°C for 24 hours before the serum is separated. Do not freeze whole blood.)
- If a centrifuge is **not** available, keep blood in a refrigerator until there is complete retraction of the clot from the serum. (If the blood sample can be transported to the testing laboratory within 24 hours, serum does not need to be separated under cold chain conditions.)
- Carefully remove the serum, avoid extracting red cells, and transfer aseptically to a sterile, screw-capped tube labeled with patient's name and/or identifier, date of collection, and specimen type.
- Store serum at 4–8°C until shipment.
- Fill in notification and investigation form completely. Three dates included in the form are essential: date of last measles vaccination; date of rash onset; and date of sample collection.

*Storage of sera until shipment:*

- Sera should be shipped to the laboratory as soon as possible on wet ice.
- If immediate shipment is not possible, sera can be stored at 4–8°C for a maximum period of seven days.
- For longer periods, sera should be frozen at –20°C. (Repeated freezing and thawing can have detrimental effects on the stability of IgM antibodies.)

*Shipment of serology specimens:*

- Specimens should be shipped to the laboratory as soon as possible; do not wait to collect additional specimens before shipping.
- Place specimens in zip-lock or plastic bags.
- Use insulated foam (e.g., Styrofoam) boxes or a thermos bottle.
- For each specimen, place the specimen form and the notification and investigation form in a plastic bag and tape to inner surface of the top of the insulated foam box.
- If using ice packs, which should be frozen, place them at the bottom of the box and along the sides, place samples in the center, and place more ice packs on top.
- Arrange a shipping date.
- When arrangements have been finalized, inform receiver of time and manner of transport.

**Results.** Only patients who have a positive result with an IgM enzyme immunoassay or who have been epidemiologically linked to another laboratory-confirmed case are considered to be laboratory-confirmed measles cases.

Collection of a second blood specimen is advisable in two circumstances. First, the original test results were equivocal. Second, when a clinician needs to make a definitive diagnosis on an individual patient with a negative result on a blood sample collected within three days of rash onset, a second sample may be useful. The second sample can be collected between 4 and 30 days after rash onset, up to 10–20 days after the first sample was collected.

### 7.2 Viral Detection/Isolation

The detection or isolation of measles virus in clinical specimens can also be used to confirm measles diagnosis, but it is relatively time-consuming and requires more sophisticated laboratory support than serology. However, recent advances have made it possible to analyze viral nucleotide sequences and establish the molecular

epidemiology of measles virus. This provides very important information concerning the likely geographic origin of measles virus importations and complements information obtained from the standard epidemiologic investigation. In addition, when vaccine-related cases are investigated, sequencing of a viral isolate allows one to discriminate vaccine and wild-type strains. **Therefore, appropriate clinical specimens for viral detection/isolation must be obtained from every chain of measles transmission as well as from all sporadic cases.**

Throat swab or nasopharyngeal samples are the preferred sample for viral isolation/detection for both measles and rubella viruses; urine samples are an acceptable alternative. Collection of both samples increases the likelihood of viral detection/isolation. Specimens for viral detection/isolation should always be collected on first contact with a patient. As the likelihood of detecting/isolating measles virus decreases rapidly in the days after rash onset, collection of specimens for viral detection/isolation should not be delayed until laboratory confirmation has occurred (i.e., until an IgM-positive test result is available).

Throat and nasopharyngeal specimens can be collected—in order of increasing virus yield—by aspiration, lavage, or swabbing of the mucous membranes. **Nasal aspirates** are collected by introducing a few milliliters of sterile saline into the nose with a syringe fitted with fine rubber tubing and collecting the fluid into a screw-capped centrifuge tube containing viral transport medium (VTM). **Throat washes** are obtained by asking the patient to gargle with a small volume of sterile saline and collecting the fluid into VTM. **Nasopharyngeal/throat swabs** are obtained by firmly rubbing the nasopharyngeal passage and throat with sterile cotton swabs to dislodge epithelial cells. The swabs are then placed in labeled screw-capped tubes containing sterile VTM (or Gelatron isotonic saline solution) and refrigerated.

VTM is usually supplied by a reference laboratory. It contains Hanks' balanced salts solution (pH 7.4 with HEPES buffer), bovine albumin, penicillin/streptomycin solution, and phenol red. If VTM is not available, isotonic saline solution, tissue culture medium, or phosphate-buffered saline may be used.

Nasopharyngeal/throat specimens should be shipped on wet ice at 4–8°C and should arrive at the testing laboratory within 48 hours. If arrangements cannot be made for rapid shipment, swabs should be shaken in the medium to elute the cells and then removed from the tubes. The medium or nasal aspirates should be centrifuged at 500g (approximately 1500 rpm) at 4°C for 5 minutes. The resulting pellet should be resuspended in cell culture medium. The resuspended pellet and the supernatant are then stored separately at –70°C and shipped to the testing laboratory on dry ice in well-sealed, screw-capped vials to protect against $CO_2$ contamination.

The first **urine** passed during the morning should be collected (most of the

measles virus excreted in urine samples is located in epithelial cells); 10–50 ml should be collected into a sterile container and placed at 4–8°C (do not freeze). Within 24 hours of collection, the urine sample should be centrifuged at 500g (approximately 1500 rpm) at 4°C for 5 minutes. The supernatant is discarded and the sediment resuspended in 1 ml of VTM (e.g., Hanks' balanced salts solution). If shipment to a measles reference laboratory is possible within 48 hours, the sediment should not be frozen. The resuspended pellet should then be stored at 4°C. If shipment within 48 hours is not possible, the resuspended pellet may be frozen at –70°C in VTM and shipped on dry ice in a well-sealed screw-capped vial (to protect against $CO_2$ contamination). If centrifugation is not possible at the site of urine collection, the whole urine should be shipped to the measles reference laboratory within 24 hours of collection in well-sealed containers at 4°C.

Measles virus is present in peripheral blood **lymphocytes** in the early stages of the disease, especially within the first 72 hours. Five to ten milliliters of blood is drawn by venipuncture into a heparinized tube which is immediately and gently inverted several times to prevent clotting. The heparinized blood must be transported immediately to the laboratory at 4–8°C for lymphocyte separation and culture.

Humans are the only natural host of measles, but measles virus can be grown in vitro in a variety of cell cultures and lines. An Epstein-Barr virus-transformed, B lymphoblastoid cell line, referred to as B95a, is the preferred cell line for primary isolation of measles virus. Great care must be exercised in using this cell line because of the presence of Epstein-Barr virus in the culture medium. Some of the original clinical specimen should be saved as it can be used for a second isolation attempt if problems occur with the first, as well as to provide a specimen for polymerase chain reaction analysis.

## 8. RESPONSE TO MEASLES OUTBREAK

Because measles virus continues to circulate in many parts of the world and international travel is common, importations of measles virus into measles-free areas can be expected to occur. Therefore, high levels of population immunity must be maintained in measles-free areas to reduce the possibility that measles will spread following an importation.

Experience has shown that, because of the very high communicability of measles, many susceptible persons will already have been infected with measles virus before an outbreak is recognized and control activities can be implemented. Although effective control of an outbreak may be very difficult, an appropriate public health response must be made (see Boxes 7 and 8).

In response to a measles outbreak, the three principal activities are to investigate

the outbreak, to treat suspected and confirmed cases, and to vaccinate susceptible individuals.

**Outbreak investigation** (see Box 9). During a measles elimination program, a single laboratory-confirmed measles case is considered to be a confirmed measles outbreak. Whenever a patient is suspected of having measles, outbreak control measures and a detailed investigation should be initiated without waiting for laboratory confirmation. Health authorities will have to evaluate each suspected case individually to determine the degree of suspicion of the notified case and what immediate actions are required.

**Box 7. STEPS IN RESPONSE TO A MEASLES OUTBREAK**

- Isolate in household and investigate suspected cases.
- Obtain appropriate blood specimens for confirmation, as well as specimens for viral detection/isolation.
- Inform other health authorities.
- Assess coverage in affected and surrounding areas.
- Provide measles vaccine to unvaccinated persons.
- Enhance surveillance, including active case-searches for further suspected cases.
- Analyze/summarize outbreak.

For single suspected cases and during the early phases of an outbreak, each case and their contacts should be completely investigated with specimens collected for serology and for viral isolation.

In large outbreaks, once five to ten suspected patients have been sampled (e.g., every third or fourth suspected case can be sampled) and the presence of measles virus circulation has been confirmed, blood does not need to be collected from every suspected case. During an outbreak, patients in whom a health care provider strongly suspects measles infection may, for surveillance purposes, be considered to be confirmed via epidemiologic link. When the number of reported suspected cases has decreased to low levels, the collection of blood specimens may be useful in order to document the end of the outbreak. Limiting the number of blood specimens collected will save valuable staff time and prevent overloading the laboratories.

All chains of measles transmission should have at least one successful viral detection/isolation. To make that possible, five to ten suspected patients typically need to be sampled. If the transmission chain continues over an extended period, further suspected patients should be sampled at intervals of two to three months. Characteristics of the detection/isolation genotype will provide information on the origin of the infection, in particular whether the virus was imported and from which region. If no evidence for importation is found, silent endemic transmission may be occurring.

**Case management.** Clinical case management of every child suspected or confirmed of having measles is critical to reducing the immediate and long-term consequences of an infection. General support, treatment of dehydration with oral rehydration solution, and vitamin A supplementation were addressed in Section 3.4. Parents or caregivers should be informed of the potential complications of measles

## Box 8. POINTS TO CONSIDER AT THE START OF AN OUTBREAK

| | |
|---|---|
| POPULATION DATA | Obtain most recent population size and age distribution. |
| WHAT HAS BEEN DONE | List any actions already taken. |
| CASE REVIEW | List reports of confirmed and suspected cases in area during previous six months. |
| COVERAGE RATES | Obtain existing coverage data and include unofficial estimates. |
| SPOT MAP | Use push-pins or a pen to mark the residences of confirmed and suspected cases (use a different color for confirmed and suspected) and areas targeted for immunization on a map. |
| RESOURCES | Determine what resources are available at all levels for outbreak control (transportation, vaccine, cold chain materials, promotional materials, etc.). Human resources should include field staff to assist in the outbreak, including staff from other programs, district staff, medical and nursing students, interpreters, and drivers. Arrange for transport and for travel advances. |
| ARRIVALS | Inform appropriate health/community authorities when and where any special teams will be arriving, and ensure that specific health staff/community representatives will be present. |
| SUPPLIES | Organize necessary supplies:<br>1. Adequate vaccine based on estimated target population;<br>2. Cold chain materials: ice packs, cold boxes, vaccine carriers, thermometers, refrigeration capacity (locally available or must be brought in). Consider purchasing ice locally;<br>3. Adequate supply of the following forms:<br>• Notification and investigation form<br>• Census chart for the investigation of suspected cases and their contacts<br>• Line-listing of suspected measles cases<br>• Summary of control measures for measles outbreaks; and<br>4. Promotional materials: pamphlets, posters, etc. |

and when and where to take their child in the event of complications. They should also be instructed about home management of common mild symptoms such as fever and diarrhea. Local clinic and hospital staff should be provided training on the clinical management of children with measles infection.

**Evaluation of vaccination coverage.** Vaccination coverage data should be reviewed as soon as a measles outbreak is suspected. Persons and areas potentially at risk for

## Box 9. GENERAL GUIDELINES FOR INVESTIGATION OF MEASLES OUTBREAKS

**1 Confirm clinical suspicion**

- Serological testing of suspected cases
  - Collect one blood specimen at first contact
- Attempt viral detection/isolation
  - Collect appropriate specimens, such as throat swab, nasopharyngeal swab/aspirate, and urine
- Establish epidemiological link to a laboratory-confirmed case

**2 Identify and investigate suspected measles cases (questions to be investigated)**

- Occupation (e.g., health care, tourism industry, etc.)
- Age, sex, residence
- Date of rash onset
- Date of last measles vaccination/number of doses received
- Date of collection of blood sample
- Date of collection of specimens for viral detection/isolation
- Possible source and location of exposure 7–21 days prior to rash onset
- Exposure to another laboratory-confirmed measles case?
- Travel to foreign countries within 7–21 days prior to rash onset? Known measles virus circulation in those countries?
- Possible transmission to others four days prior to or four days after rash onset?
- Where was the patient born?
- When did the patient move to current residence?
- Have there been other cases within the household?
- Have there been other cases in the neighborhood?
- Where does the patient work/study?
- How does the patient commute to work/school?
- Are there other cases in the workplace/school?
- Where does the patient socialize (market, church, club, school, etc.)?
- Are there other cases in these social groups?

**3 Describe the outbreak (descriptive epidemiology)**

- Total number of confirmed cases
- Age distribution and vaccination status of confirmed measles cases
- In which municipalities is measles virus circulating? (maps)
- In each affected municipality, what was the age and vaccination status of the first case?
- How long did the outbreak last? (epi-curve)

**4 Determine source of outbreak**

- Classical epidemiology (Who acquired infection from whom? Where and when?)
- Molecular epidemiology via genotypic analysis of detected/isolated measles virus

measles transmission should be identified. The priority of the vaccination activity is to provide measles vaccination to previously unvaccinated infants and children.

The use of the rapid coverage monitoring tool as described above should serve as the model for assessing whether vaccination activities are warranted.

**Measles vaccination.** There are very few contraindications to receiving measles vaccine, and the following recommendations serve as a general guide. Specific measures must be based on the prevailing epidemiologic situation in the outbreak area.

Vaccination within 72 hours of exposure may help prevent the disease or mitigate its severity.

**Whom to vaccinate:** When a measles outbreak is suspected, all children 1 to 15 years of age without a history of measles vaccination should be vaccinated. If the outbreak is large and many cases are occurring in infants aged less than 12 months, the age of routine vaccination should be decreased to 6 months. These infants should be revaccinated when they reach 1 year of age.

All health workers must be vaccinated. Children hospitalized or attending outpatient clinics for any reason and who cannot provide written proof of measles vaccination should be vaccinated with measles vaccine, if not contraindicated. In addition, vaccination of adolescents and young adults residing or working in institutions, such as military bases, university dormitories, hospitals, and factories, should be considered.

**When to vaccinate:** Vaccination of previously unvaccinated persons should start immediately when a measles outbreak is suspected, without waiting for laboratory confirmation of suspected cases. If the suspected cases are eventually confirmed in a laboratory, the vaccination intervention would have helped to decrease the number of susceptible children, and contribute to the interruption of measles virus transmission. If the initial suspected cases do not turn out to be measles, then the vaccination activity has helped to raise the level of measles immunity in the community and to prevent future measles outbreaks.

**Where to vaccinate:** In both urban and rural areas, the focus of vaccination efforts should target pockets of susceptible infants and children (i.e., any individuals without proof of measles vaccination). The largest possible area should be covered. Gathering points such as schools, churches, and health posts may be chosen as mass vaccination sites.

**Measles cases at ports of entry.** The following guidelines may be useful in dealing with international passengers who are suspected of being infected with measles.

Any traveler who is suspected of having measles should immediately be referred to local health authorities. The passenger should be informed of his/her illness and its potential for complications and transmission to others. If hospitalization is not necessary, the patient with suspected measles infection should remain at a residence (hotel or other living quarters) until at least five days after rash onset.

A health information card should be given routinely to all travelers arriving or visiting from other countries. It should inform them of the measles elimination program and request that they assist by seeking immediate medical attention if they experience any fever and rash illness.

**Cross-notification.** Health authorities at all levels should be informed of and involved in all aspects of surveillance and outbreak response. Health officials in

nearby jurisdictions also should be notified and updated as frequently as possible, so that they may begin appropriate preventive actions as needed. If an importation is suspected, the local health officials in the country from which the case was imported should be provided with full details (see Annex 13). If a suspected case has traveled or had close contact with individuals from other areas of the country 7–21 days before the onset of the illness, the surveillance coordinators in those areas should be notified immediately. Neighboring countries should be notified as well. The public should be informed through the media about the outbreak and any control efforts being undertaken (see Annex 14).

**Enhancement of surveillance.** As part of the response to a measles outbreak, measles surveillance should be intensified to search for additional suspected cases. All reporting units should be notified of the suspected measles outbreak and be alerted to be "on the lookout" for additional cases. Daily calls or visits to schools, hospital emergency rooms, and selected pediatricians may prove useful, especially in urban areas. The number and extent of active case-searches must be increased.

**Outbreak monitoring.** Information on suspected and confirmed measles cases, vaccination activities, and areas visited should be monitored and updated continuously during an outbreak. This information should be recorded in such a way that it can be summarized quickly on a form for control measures for measles outbreaks (see Annex 15). When no new cases are reported during a three-week period, despite the presence of enhanced surveillance, the outbreak may be considered to be at an end.

**Outbreak summary.** Careful investigation of measles outbreaks can provide useful information regarding factors that may have facilitated measles virus circulation. The investigation may help to identify risk factors for measles infection and provide information that can be used to refine and improve the measles elimination program.

To benefit from the investigation and outbreak control activities, data and conclusions from the outbreak need to be published. The report should include the following sections: introduction; surveillance methods; description of the outbreak; analysis of the outbreak; control measures; problems; and conclusions and recommendations.

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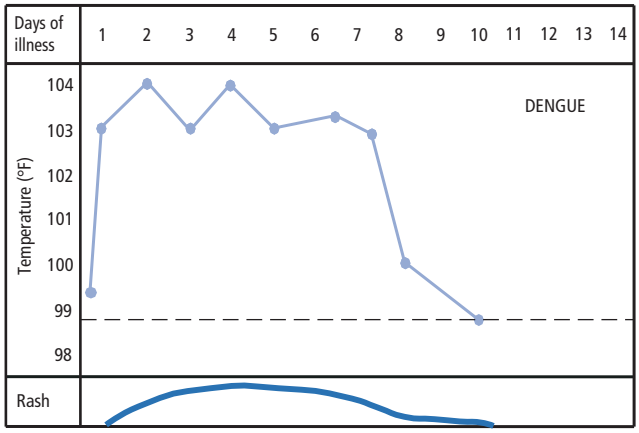
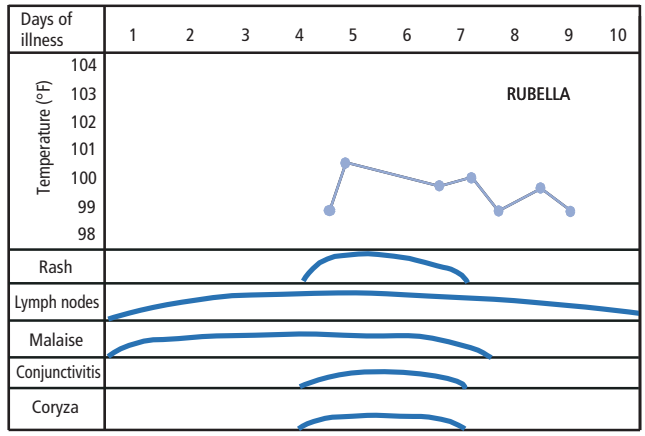
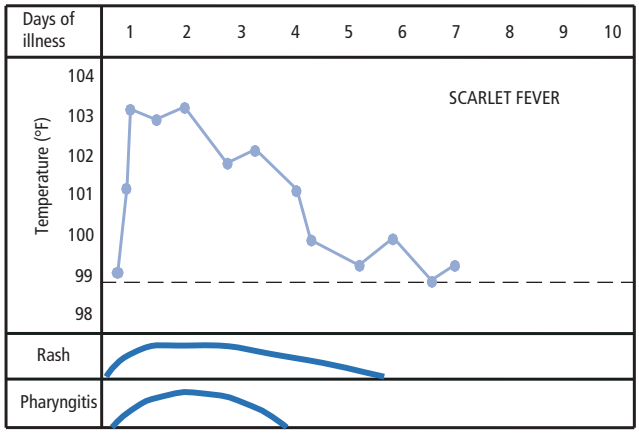
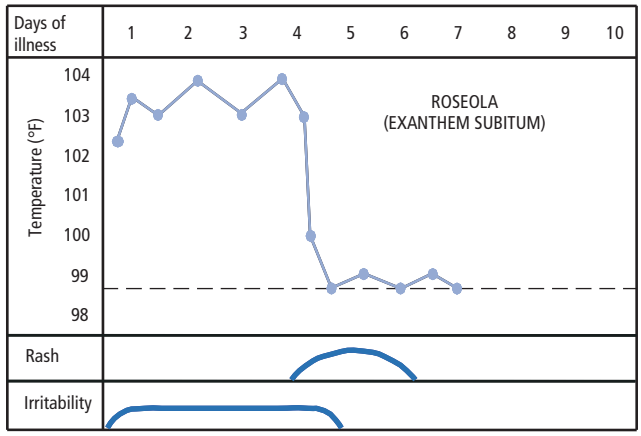
# ANNEXES

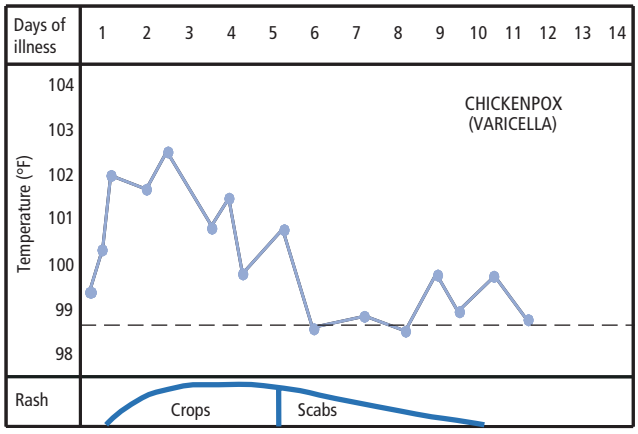
# ANNEX 1. Typical clinical course of rash illnesses that are differential diagnoses to measles




Source: Adapted from Krugman S. Diagnosis of acute exanthematous diseases. In: Gershon AA, Hotez PJ, Katz SL (eds.). *Krugman's Infectious Diseases of Children,* 11th ed. St. Louis: Mosby; 2004: Figure 45-1, p. 927, with permission from Elsevier.

# ANNEX 2. Rapid monitoring of measles vaccine coverage

State/Province: _____ District: _____

Municipality: _____ Neighborhood/block: _____

Responsible for vaccination: _____ Responsible for monitoring: _____

Date of monitoring: _____

| (A) House # | (B) Number of children aged 1–4 years living in the house | (C) Number of those children with proof of measles vaccination (card, certificate, other) | (D) Reason given by parents why child was not vaccinated | (E) Other observations* |
|---|---|---|---|---|
| 1 | | | | |
| 2 | | | | |
| 3 | | | | |
| 4 | | | | |
| 5 | | | | |
| 6 | | | | |
| 7 | | | | |
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| 17 | | | | |
| 18 | | | | |
| 19 | | | | |
| 20 | | | | |
| 21 | | | | |
| 22 | | | | |
| 23 | | | | |
| 24 | | | | |
| 25 | | | | |
| **TOTAL** | | | | |

* If a door-to-door campaign is conducted, indicate if vaccinators did not come, if house was properly marked, etc.
Note: the monitoring ends when a total of 20 households with eligible children have been visited. If no adult is present to show proof of measles vaccination, mark "excluded" in column B and do not consider household in the coverage calculation.

$$\text{Measles vaccine coverage in surveyed households} = \frac{\text{(C) Vaccinated children}}{\text{(B) Total number of surveyed children}} \times 100 = \boxed{\phantom{00}}$$

# ANNEX 3. Notification and Investigation Form - MEASLES / RUBELLA

[Name of institution] **Notification and Investigation Form – MEASLES / RUBELLA**

Case number _____ Service _____

State/Province _____ District _____

Municipality _____ Neighborhood/Landmarks _____

Informant _____ Telephone _____

## I CASE IDENTIFICATION

First and last name _____

Address _____

Telephone _____ Mother's name _____

Sex ☐ male ☐ female Date of birth ____ (Day) ____ (Month) ____ (Year) Father's name _____

If date of birth unavailable, age Years _____ Months _____ Days _____

## II BACKGROUND

Notification date ____ (Day) ____ (Month) ____ (Year) Home visit date ____ (Day) ____ (Month) ____ (Year)

Case was detected in ☐ Hospital ☐ Practice/health unit ☐ Laboratory Sector where case detected ☐ Public ☐ Private

Case identified by: ☐ Spontaneous consultation (passive) ☐ Institutional search ☐ Community case-search ☐ Laboratory submission ☐ Investigation of contacts ☐ Others

Contact with confirmed case ☐ Yes ☐ No ☐ Unk If contact with confirmed case, case # _____

Number of doses of measles-containing vaccine ☐ 0 ☐ 1 ☐ ≥ 2 ☐ Unk Date of last dose of vaccine ____ (Day) ____ (Month) ____ (Year)

Number of doses of rubella-containing vaccine ☐ 0 ☐ ≥ 1 ☐ Unk Date of last dose of rubella-containing vaccine ____ (Day) ____ (Month) ____ (Year)

Vaccination information obtained by: ☐ Vaccination card ☐ Health services ☐ Parents or another adult (child) ☐ Self (adult)

## III CLINICAL DATA, FOLLOW-UP, AND TREATMENT

Patient suspected of ☐ Measles ☐ Rubella

**Signs and symptoms**

| | | | |
|---|---|---|---|
| Fever (grade _____ ) | ☐ Yes | ☐ No | ☐ Unk |
| Rash (duration _____ days) | ☐ Yes | ☐ No | ☐ Unk |
| Cough | ☐ Yes | ☐ No | ☐ Unk |
| Conjunctivitis | ☐ Yes | ☐ No | ☐ Unk |
| Coryza | ☐ Yes | ☐ No | ☐ Unk |
| Adenopathy (place _____ ) | ☐ Yes | ☐ No | ☐ Unk |
| Arthralgia (joints _____ ) | ☐ Yes | ☐ No | ☐ Unk |

**Complications**

Date of fever onset ____ (Day) ____ (Month) ____ (Year)

Date of rash onset ____ (Day) ____ (Month) ____ (Year)

Rash type ☐ Maculopapular ☐ Other rash type ☐ Vesicular ☐ Unknown

Pregnant ☐ Yes, weeks _____ ☐ No ☐ Unk

Contact with pregnant women (if yes, _____ gestation weeks) ☐ Yes ☐ No ☐ Unk

Hospitalization ☐ Yes ☐ No ☐ Unk Admission date ____ (Day) ____ (Month) Registry/history # _____

Name of hospital _____ Date of discharge/death ____ (Day) ____ (Month)

Final status ☐ Recovered ☐ Transferred to _____ ☐ Dead ☐ Unknown

## IV SAMPLES AND LABORATORY ANALYSIS

| | SAMPLE 1 | SAMPLE 2 | SAMPLE 3 | SAMPLE 4 |
|---|---|---|---|---|
| Type of sample | ☐ Nasopharyngeal aspirate/swab<br>☐ Throat swab<br>☐ Serum<br>☐ Urine<br>☐ Other: _____ | ☐ Nasopharyngeal aspirate/swab<br>☐ Throat swab<br>☐ Serum<br>☐ Urine<br>☐ Other: _____ | ☐ Nasopharyngeal aspirate/swab<br>☐ Throat swab<br>☐ Serum<br>☐ Urine<br>☐ Other: _____ | ☐ Nasopharyngeal aspirate/swab<br>☐ Throat swab<br>☐ Serum<br>☐ Urine<br>☐ Other: _____ |
| Identification # | | | | |
| Date taken | Day / Month / Year | Day / Month / Year | Day / Month / Year | Day / Month / Year |
| Date sent | | | | |
| **FOR LABORATORY USE** | | | | |
| Date received | Day / Month / Year | Day / Month / Year | Day / Month / Year | Day / Month / Year |
| Laboratory name | | | | |
| Id # in laboratory | | | | |
| Type of test | ☐ IgM EIA capture<br>☐ IgM EIA indirect<br>☐ IgG EIA<br>☐ Viral isolation<br>☐ PCR<br>☐ Other test _____ | ☐ IgM EIA capture<br>☐ IgM EIA indirect<br>☐ IgG EIA<br>☐ Viral isolation<br>☐ PCR<br>☐ Other test _____ | ☐ IgM EIA capture<br>☐ IgM EIA indirect<br>☐ IgG EIA<br>☐ Viral isolation<br>☐ PCR<br>☐ Other test _____ | ☐ IgM EIA capture<br>☐ IgM EIA indirect<br>☐ IgG EIA<br>☐ Viral isolation<br>☐ PCR<br>☐ Other test _____ |
| Antigen tested | ☐ Measles<br>☐ Rubella<br>☐ Dengue<br>☐ Other Ag _____ | ☐ Measles<br>☐ Rubella<br>☐ Dengue<br>☐ Other Ag _____ | ☐ Measles<br>☐ Rubella<br>☐ Dengue<br>☐ Other Ag _____ | ☐ Measles<br>☐ Rubella<br>☐ Dengue<br>☐ Other Ag _____ |
| Results | ☐ Positive<br>☐ Negative<br>☐ Indeterminate<br>☐ Inadequate sample<br>☐ Not processed | ☐ Positive<br>☐ Negative<br>☐ Indeterminate<br>☐ Inadequate sample<br>☐ Not processed | ☐ Positive<br>☐ Negative<br>☐ Indeterminate<br>☐ Inadequate sample<br>☐ Not processed | ☐ Positive<br>☐ Negative<br>☐ Indeterminate<br>☐ Inadequate sample<br>☐ Not processed |
| Result dates | Day / Month / Year | Day / Month / Year | Day / Month / Year | Day / Month / Year |
| Comments | | | | |

## V INVESTIGATION

| | | | |
|---|---|---|---|
| Active case-search from this suspected case | ☐ Yes ☐ No ☐ Unk | Further suspected cases found in active case-search<br>☐ Yes, how many? _____ ☐ No ☐ Unk | |
| Travel abroad 7–23 days before rash onset | ☐ Yes, country _____ | ☐ No | ☐ Unknown |
| Date travel started | Day / Month / Year | Date travel ended | Day / Month / Year |

## VI CLASSIFICATION

| | | | |
|---|---|---|---|
| Final classification | ☐ Confirmed as measles | ☐ Confirmed as rubella | ☐ Discarded |
| Basis for classification | ☐ Laboratory results | ☐ Epidemiological link | ☐ Clinical presentation |
| Basis for discarding | ☐ Measles/rubella IgM-neg.<br>☐ Positive for dengue | ☐ Other diagnosis: _____ | ☐ Vaccine reaction<br>☐ Unknown |
| For confirmed cases, source of infection | ☐ Imported | ☐ Import-related | ☐ Unknown source |
| Classified by (Name) | | Date classified | Day / Month / Year |

| | | | |
|---|---|---|---|
| Investigator | | Telephone | |
| Institution | | | |
| Signature | | Date | |

# ANNEX 4. Weekly surveillance report

## WEEKLY SPECIAL SURVEILLANCE REPORT

REPORTING UNIT: _____

DATES: from _____ to _____

1. NUMBER OF SUSPECTED MEASLES CASES: _____
   (Attach forms on any case; if no cases to report, indicate 0.)

2. NUMBER OF ACUTE FLACCID PARALYSIS CASES: _____
   (Attach forms on any case; if no cases to report, indicate 0.)

3. OTHER: _____ ; _____
   (Other designated disease or condition.)

Person filling out report: _____
Date : _____

PLEASE SEND BY MESSENGER, TELEPHONE, OR FAX BY TUESDAY.

# ANNEX 5. Sample letter to elicit collaboration of private physicians

27 September 2004

Dear Doctor:

The Ministry of Health has joined with other World Health Organization member countries in a Measles Elimination Campaign. You probably remember the successful immunization campaign that was conducted in May of 2004.

A national Measles Surveillance System has been developed to keep track of all suspected cases of measles. As the incidence of measles falls, the need to monitor other infectious diseases with exanthems becomes more important; these include dengue, scarlet fever, rubella, coxsackie, chickenpox, roseola, etc.

Measles is a highly transmissible, acute infectious viral disease. You should suspect measles in patients presenting with the following signs and symptoms:

- high fever;
- generalized or blotchy rash;
- cough, coryza, or conjunctivitis.

We are requesting your participation in our Measles Surveillance System. Please report any patient of any age in whom you suspect measles infection. Enclosed is the surveillance form we are asking that you complete on each patient with suspected measles. May we suggest that your receptionist/nurse be provided with these forms and instructed to include this form whenever a patient has suspected measles.

In addition, if you see a patient with suspected measles infection, please contact your local Health Officer, Dr. Eric Smith, at (678) 555–4321 as soon as possible. In order to confirm measles infection in the laboratory, we will need to collect a blood specimen. If needed, we can assist either with the collection or pick-up of the specimen.

Thank you for your cooperation. It will be a pleasure to work with you in this program.

Yours faithfully,

Dr. Samuel Jones
Senior Medical Officer of Health

Encl: Surveillance Form

# ANNEX 6. Laboratory line-listing (measles serology)

| LABORATORY _____ | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Country | Case ID | Laboratory No. | Date of measles vaccination | Date of rash onset | Date blood sample taken | Date specimen received | Condition of specimen* | Was the sample sufficient?** | Type of test | Date of results | Results | Observations |
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* Adequate or inadequate

** Yes or no

# Annex 7. Line-listing of suspected measles cases

| CASE ID | NAME | COUNTY/ MUNICIPALITY | AGE | DOSES RECEIVED | DATE OF LAST VACCINE | NOTIFICATION DATE | CONTACT WITH OTHER CONFIRMED CASE (YES/NO) | FEVER (YES/NO) | DATE OF RASH ONSET |
|---|---|---|---|---|---|---|---|---|---|
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## Annex 7. continued

| PROGRESSION IN DAYS/ ASCENDANT DESCENDANT | OTHER SYMPTOMS (YES/NO) | | | DATE THE LABORATORY SAMPLE WAS TAKEN | FINAL CLASSIFICATION | | | OBSERVATIONS |
|---|---|---|---|---|---|---|---|---|
| | COUGH | CORYZA | CONJUNCTIVITIS | | CONFIRMED IN LABORATORY | CLINICALLY CONFIRMED | DISCARDED | |
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# ANNEX 8. Census chart for the investigation of suspected measles cases and their contacts

Full address of house or workplace visited: _____

State/province, district, municipality, neighborhood/block: _____

| ALL HOUSEHOLD MEMBERS / WORKERS AND REGULAR VISITORS | | | | | ONLY SUSPECTED CASES | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| (1) Name* | (2) Birth date | (3) Sex (M/F) | (4) Total number of measles vaccine doses and date of last dose | (5) Suspected measles case (Yes/No) | (6) Date of rash onset | (7) Samples taken: serum, naso-pharyngeal aspirate, throat swab, urine | (8) Places visited 7–21 days before rash onset (possible exposure sites) | (9) Date(s) of investigation of places described in column 8 | (10) Places visited four days before to four days after rash onset | (11) Date(s) of investigation of places described in column 10 | (12) Other information (e.g., death, occupation, contact with tourist) |
| | | | | | | | | | | | |
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*__Note:__ Interview all persons who live or work there and those who visited this location within 7–21 days prior to rash onset and/or since beginning of first respiratory symptoms up to four days after rash onset. Also, interview here the suspected patient that originated the investigation. Vaccination status (column 4) must be verified through vaccination card or other written document; if unavailable write down "unknown." The supervisor decides who is suspected based on the case definition (e.g., rash and fever plus cough, conjunctivitis, or coryza).

Person in charge of investigation: _____ Date of investigation: _____

# ANNEX 9. Distribution of diagnoses for discarded cases of suspected measles

| Jurisdiction:_____ | | | | | | |
|---|---|---|---|---|---|---|
| | YEAR | | | | | |
| | 20___ | | 20 ___ | | 20 ___ | |
| **Diagnosis** | # | % | # | % | # | % |
| RUBELLA | | | | | | |
| SCARLET FEVER | | | | | | |
| DENGUE | | | | | | |
| (Other diseases or conditions) | | | | | | |
| | | | | | | |
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| | | | | | | |
| WITHOUT DIAGNOSIS | | | | | | |
| TOTALS | | | | | | |

# ANNEX 10. Summary of measles/rubella surveillance data and surveillance indicators

| Country: _____ | | | |
|---|---|---|---|
| | Years | | |
| CRITERIA | 20___ | 20___ | 20___ |
| **Measles surveillance data** | | | |
| Number of suspected measles cases reported | | | |
| Number of confirmed measles cases in the laboratory | | | |
| Number of clinically confirmed measles cases | | | |
| Number of suspected measles cases discarded | | | |
| **Rubella surveillance data** | | | |
| Number of suspected rubella cases reported | | | |
| Number of confirmed rubella cases in the laboratory | | | |
| Number of clinically confirmed rubella cases | | | |
| Number of suspected rubella cases discarded | | | |
| **Surveillance indicators** | | | |
| Percentage of sites reporting weekly | | | |
| Percentage of suspected cases that were investigated adequately | | | |
| Percentage of suspected cases with home visit within 48 hours of notification | | | |
| Percentage of suspected cases with complete relevant data | | | |
| Percentage of suspected cases for which active case-searches were carried out | | | |
| Percentage of suspected cases with a blood specimen collected within 30 days of rash onset or epidemiologic link to a laboratory-confirmed case | | | |
| Percentage of suspected cases with a blood specimen received at the laboratory within five days of collection | | | |
| Percentage of suspected cases with a blood specimen processed within four days of laboratory reception | | | |
| Percentage of suspected cases that were laboratory discarded | | | |
| Percentage of chains of transmission with representative samples for viral isolation | | | |

# ANNEX 11. *Measles and Rubella Weekly Bulletin*

**Pan American Health Organization**
*Regional Office of the* World Health Organization

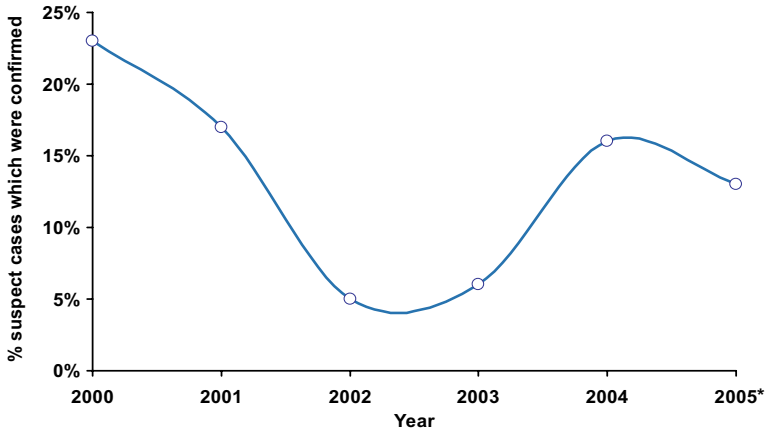
**Immunization Unit**
***Family and Community Health Area***
**Measles / Rubella Weekly Bulletin**

***Vol.11, No. 34***

## Measles and Rubella Surveillance in the Americas

***Week ending 27 August 2005***

### Proportion of Suspect Cases Which Were Confirmed as Rubella—The Americas, 2000–2005*




* As of Epidemiological Week 34 2005
Source: Countries reporting through the Measles Elimination Surveillance System

**Table No. 1**
**Classification of Suspected Measles, Rubella, & Congenital Rubella Syndrome (CRS) Cases for the Period Between Weeks 01-34, 2005**

| Subregion | and Country | Suspected Cases 2005 | Measles Confirmed 2005 | | | Year/Week Last Confir. Measles Case | Rubella Confirmed 2005 | | | Year/Week Last Confir. Rubella Case | Diagnosis of Discarded Cases 2005 | | Congenital Rubella Syndrome | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | Clinic. | Lab. | Total | | Clinic. | Lab. | Total | | Dengue | Other | Suspec. | Confir. |
| AND | BOL | 161 | 0 | 0 | 0 | 00/40 | 0 | 4 | 4 | 05/19 | 17 | 138 | ... | ... |
| | COL | 967 | 0 | 0 | 0 | 02/39 | 3 | 15 | 18 | 05/33 | 17 | 917 | 93 | 3 |
| | ECU | 248 | 0 | 0 | 0 | 01/14 | 0 | 0 | 0 | 04/45 | 23 | 225 | ... | ... |
| | PER | 1891 | 0 | 0 | 0 | 00/13 | 0 | 675 | 675 | 05/33 | 5 | 1008 | 1126 | 1 |
| | VEN | 1716 | 0 | 0 | 0 | 02/47 | 0 | 177 | 177 | 05/34 | 92 | 1447 | ... | ... |
| BRA | BRA | 9944 | 0 | 6 | 6 | 05/29 | 43 | 54 | 97 | 05/33 | 0 | 8862 | 75 | 0 |
| CAP | COR | 5 | 0 | 0 | 0 | 03/47 | 0 | 0 | 0 | 01/42 | 0 | 0 | 0 | 0 |
| | ELS | 70 | 0 | 0 | 0 | 01/19 | 0 | 0 | 0 | 03/31 | 10 | 58 | ... | ... |
| | GUT | 284 | 0 | 0 | 0 | 98/05 | 0 | 3 | 3 | 05/31 | 1 | 280 | 0 | 0 |
| | HON | 161 | 0 | 0 | 0 | 97/29 | 0 | 0 | 0 | 04/11 | 39 | 99 | 36 | 0 |
| | NIC | 193 | 0 | 0 | 0 | 94/14 | 0 | 0 | 0 | 04/19 | 9 | 184 | 0 | 0 |
| | PAN | 224 | 0 | 0 | 0 | 95/49 | 0 | 0 | 0 | 02/48 | 11 | 210 | 0 | 0 |
| CAR | CAR | 138 | 0 | 0 | 0 | 98/23 | 0 | 0 | 0 | 01/27 | 4 | 133 | 0 | 0 |
| LAC | CUB | 878 | 0 | 0 | 0 | 93/27 | 0 | 0 | 0 | 04/11 | 0 | 682 | 0 | 0 |
| | DOR | 148 | 0 | 0 | 0 | 01/23 | 0 | 6 | 6 | 05/20 | 2 | 131 | ... | ... |
| | FGU | 91 | 0 | 0 | 0 | ... | ... | ... | ... | ... | 36 | 55 | ... | ... |
| | GUA | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... |
| | HAI | 18 | 0 | 0 | 0 | 01/39 | 0 | 0 | 0 | 04/25 | 1 | 14 | 0 | 0 |
| | MAR | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... |
| | PUR | 0 | 0 | 0 | 0 | | 0 | 0 | 0 | | ... | ... | 0 | 0 |
| MEX | MEX | 2805 | 0 | 1 | 1 | 05/14 | 6 | 19 | 25 | 05/34 | 0 | 1826 | 0 | 0 |
| NOA | CAN | 311 | 0 | 3 | 3 | 05/14 | 0 | 308 | 308 | 05/25 | ... | ... | ... | ... |
| | USA | 64 | 0 | 56 | 56 | 05/31 | 0 | 8 | 8 | 05/30 | ... | ... | 1 | 1 |
| SOC | ARG | 267 | 0 | 0 | 0 | 00/11 | 0 | 0 | 0 | 04/50 | 0 | 227 | 5 | 0 |
| | CHI | 375 | 0 | 0 | 0 | 03/19 | 11 | 29 | 40 | 05/21 | 0 | 311 | 95 | 0 |
| | PAR | 322 | 0 | 0 | 0 | 98/44 | 0 | 2 | 2 | 05/21 | 1 | 319 | 4 | 0 |
| | URU | 8 | 0 | 0 | 0 | 99/08 | 0 | 0 | 0 | 01/37 | 0 | 8 | 0 | 0 |
| TOTAL | | 21289 | 0 | 66 | 66 | --- | 63 | 1300 | 1363 | --- | 268 | 17134 | 1435 | 5 |

... No report received

**Table No. 2**
**Infection Source of Measles and Rubella Confirmed Cases for the Period Between Weeks 01-34, 2005**

| Subregion | Country | Measles | | | Rubella | | | |
|---|---|---|---|---|---|---|---|---|
| | | I | IR | U | I | IR | U | IN |
| AND | BOL | | | | | | | |
| | COL | | | | | | | |
| | ECU | | | | | | | |
| | PER | | | | | | | |
| | VEN | | | | | | | |
| BRA | BRA | 1 | 5 | | | | | 97 |
| CAP | COR | | | | | | | |
| | ELS | | | | | | | |
| | GUT | | | | | | | |
| | HON | | | | | | | |
| | NIC | | | | | | | |
| | PAN | | | | | | | |
| CAR | CAR | | | | | | | |
| LAC | CUB | | | | | | | |
| | DOR | | | | | | | |
| | FGU | | | | | | | |
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| | HAI | | | | | | | |
| | MAR | | | | | | | |
| | PUR | | | | | | | |
| MEX | MEX | 1 | | | | | 22 | |
| NOA | CAN | 2 | 1 | | | | | |
| | USA | 14 | 36 | 2 | 1 | | 3 | |
| SOC | ARG | | | | | | | |
| | CHI | | | | | | | 40 |
| | PAR | | | | | | 2 | |
| | URU | | | | | | | |
| TOTAL | | 18 | 42 | 2 | 1 | | 27 | 137 |

I: Imported – IR: Import-related – U: Unknown – IN: Indigenous

**Table No. 3**
**Measles/Rubella Suspected Cases Under Investigation for the Period Between Weeks 01-34, 2005**

| Country | Pending Cases 2004 | Cumulative 2005 | Week of Rash Onset | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | | 1-29 | 30 | 31 | 32 | 33 | 34 | Unkn. |
| BOL | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | |
| COL | 0 | 9 | 4 | 0 | 0 | 0 | 3 | 1 | 1 |
| ECU | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | |
| PER | 0 | 3 | 2 | 0 | 0 | 1 | 0 | 0 | |
| VEN | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | |
| BRA | 0 | 981 | 371 | 86 | 131 | 131 | 262 | … | |
| COR | 0 | 4 | 4 | 0 | 0 | 0 | 0 | 0 | |
| ELS | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | |
| GUT | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | |
| HON | 0 | 5 | 1 | 0 | 2 | 1 | 1 | 0 | |
| NIC | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | |
| PAN | 0 | 1 | 1 | 0 | 0 | 0 | 0 | 0 | |
| CAR | 0 | 1 | 1 | 0 | 0 | 0 | 0 | 0 | |
| CUB | 0 | 196 | 103 | 34 | 0 | 0 | 59 | 0 | |
| DOR | 0 | 5 | 2 | 0 | 0 | 3 | 0 | 0 | |
| FGU | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | |
| GUA | … | … | … | … | … | … | … | … | |
| HAI | 0 | 2 | 2 | 0 | 0 | 0 | 0 | 0 | |
| MAR | … | … | … | … | … | … | … | … | |
| PUR | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | |
| MEX | 0 | 953 | 905 | 19 | 14 | 10 | 4 | 1 | |
| CAN | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | |
| USA | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | |
| ARG | 0 | 10 | 2 | 1 | 0 | 2 | 0 | 0 | 5 |
| CHI | 0 | 6 | 1 | 0 | 1 | 1 | 1 | 2 | |
| PAR | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | |
| URU | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | |
| TOTAL | 0 | 2176 | 1399 | 140 | 148 | 149 | 330 | 4 | 6 |

... No report received

**Table No. 4**
**Indicators of Integrated Measles/Rubella Surveillance for the Period Between Weeks 01-34, 2005**

| Subregion | Country | % Sites Reporting Weekly | % Cases Adequate Investigation | % Cases Adequate Sample | % Lab Received <=5 days | % Lab Result <=4 days | % Cases Discarded by Lab | Chains of Transmission With Representative Samples for Viral Isolation |
|---|---|---|---|---|---|---|---|---|
| AND | BOL | 71 | 98 | 100 | 80 | 80 | 97 | |
| | COL | 93 | 51 | 96 | 73 | 89 | 99 | |
| | ECU | 78 | 60 | 98 | 77 | 92 | 99 | |
| | PER | 98 | 91 | 98 | 71 | 48 | 95 | |
| | VEN | 85 | 65 | 96 | 72 | 49 | 100 | |
| BRA | BRA | 94 | 72[a] | 75 | 42 | 89 | 89 | 1 |
| CAP | COR | 85 | 80 | 75 | 100 | 25 | … | |
| | ELS | 83 | 57 | 100 | 87 | 94 | 100 | |
| | GUT | 55 | 98 | 100 | 71 | 87 | 99 | |
| | HON | 88 | 89 | 99 | 81 | 82 | 100 | |
| | NIC | 100 | 82 | 100 | 72 | 89 | 100 | |
| | PAN | 94 | 79 | 91 | 60 | 90 | 99 | |
| CAR | CAR | 100 | 78 | 98 | 30 | 97 | 99 | |
| LAC | CUB | 98 | 85[a] | 100 | 100 | 100 | 78 | |
| | DOR | 73 | 81 | 100 | 50 | 74 | 99 | |
| | FGU | ... | ... | ... | ... | ... | ... | |
| | GUA | ... | ... | ... | ... | ... | ... | |
| | HAI | ... | 50 | 77 | 0 | 100 | 82 | |
| | MAR | ... | ... | ... | ... | ... | ... | |
| | PUR | ... | ... | ... | ... | ... | ... | |
| MEX | MEX | ... | 99[b] | ... | ... | ... | ... | 1 |
| NOA | CAN | ... | ... | ... | ... | ... | ... | |
| | USA | ... | ... | ... | ... | ... | ... | |
| SOC | ARG | 80 | 11 | 87 | 65 | 82 | 100 | |
| | CHI | 99 | 27 | 82 | 81 | 98 | 100 | 1 |
| | PAR | 91 | 63 | 100 | 91 | 100 | 99 | |
| | URU | 41 | 50 | 100 | 100 | 75 | 100 | |
| Total and Average | | 92 | 70 | 83 | 57 | 82 | 91 | 3 |

... No report received

[a] Also includes information on active case-searches
[b] Only considers home visit within 48 hours of notification

Issues of *Measles/Rubella Surveillance Bulletin* can be accessed at:
http://www.paho.org/english/ad/fch/im/measles.htm

# ANNEX 12. Summary of sites reporting weekly

INSTRUCTIONS 1) Check the corresponding case each week you receive a report on time and mark with an "1." If the report is received and is late mark with a "Z."
2) Calculate the percentage of centers that present reports on time dividing the number of centers that present on time by the total number.

| REPORTING UNITS | WEEK No. | | | | | | | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 | 20 | 21 | 22 | 23 | 24 | 25 | 26 |
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| TOTAL UNITS REPORTING | | | | | | | | | | | | | | | | | | | | | | | | | | |
| % OF UNITS THAT REPORT ON TIME | | | | | | | | | | | | | | | | | | | | | | | | | | |

## ANNEX 12. continued

| REPORTING UNITS | WEEK No. | | | | | | | | | | | | | | | | | | | | | | | | | | Total Reports | Percentage of reports on time |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 27 | 28 | 29 | 30 | 31 | 32 | 33 | 34 | 35 | 36 | 37 | 38 | 39 | 40 | 41 | 42 | 43 | 44 | 45 | 46 | 47 | 48 | 49 | 50 | 51 | 52 | | |
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| TOTAL UNITS REPORTING | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| % OF UNITS THAT REPORT ON TIME | | | | | | | | | | | | | | | | | | | | | | | | | | | | |

# ANNEX 13. Sample letter reporting a possible imported measles case to health officials of place of origin

28 May 2004

Dr. Edmond Jones
Health Officer
New York City

Dear Dr. Jones:

On May 26, 2004, we were informed by Dr. Pardo, the Medical Officer at one of our clinics, that he had seen what appeared to be a case of measles (rubeola). The affected child, Inés Torres, had just returned from a trip visiting family in Brooklyn, NY. Inés, female 20 months of age, started her illness with two days of "high" fever (no temperature was taken), followed by a maculopapular rash which appeared blotchy on the face by the second day. Dr. Pardo saw the patient on the second day of rash and observed Koplik's spots at that time. The rash had started on the face. The patient also had a cough and a runny nose and the mother relates that the child's eyes had bothered her. The child was visited by health staff on May 28; at that time she had virtually completely recovered from her illness, and only a fine, faint rash could be seen. The child had stayed with family in Brooklyn and also was cared for at a day-care center there.

Below are some details of the case:

Date of birth: September 30, 2002 (born in Peru)
Date of onset of rash: May 24, 2004
Date of onset of fever: May 21, 2004
Duration of rash: three to four days
Vaccination history: MMR December 9, 2003 (from vaccine record)
Serum specimen: Collected May 26, 2004 (to be tested for measles IgM)
Possible source of infection: aunt's home in Brooklyn, NY. Visited from May 7 to May 18
Father's name: Vincent Smith, resides in Peru
Relative's house in Brooklyn: Ms. Glynis Smith. Tel: (718) 555-1234 (Ms. Smith is reportedly a nurse. We have been unable to get the address at this time.)
Name of day-care center: Has not been provided at this time

As soon as we receive the results from the laboratory we will be forwarding this information to you. We are also interested in hearing about the results of your investigation in Brooklyn when such information is available.

Sincerely,

Senior Medical Officer of Health
Ministry of Health of Peru
Surveillance Program
Lima, Peru
TEL: (511) 555-5432
FAX: (511) 555-9876

## ANNEX 14. Measles alert notice (sample)

Children with measles have been found in your neighborhood and YOUR CHILD MAY BE AT RISK of getting this disease.

This type of measles can cause a SERIOUS ILLNESS, with pneumonia, ear infections, brain illnesses, and EVEN DEATH.

If your child has RASH and FEVER, alert a doctor or a health agent immediately.

Measles can be PREVENTED by MEASLES VACCINE. ALL CHILDREN 6 MONTHS OF AGE OR OLDER must receive the vaccine IMMEDIATELY. Even if your child is already vaccinated against measles, he or she should receive another dose so as not to catch the illness.

Measles vaccine is very safe and effective, and will help you PROTECT YOUR CHILD'S HEALTH. Take your child to the doctor or the health center to be vaccinated.

# ANNEX 15. Summary of control measures for measles outbreaks

Name of the index case: _____ Case No.: _____

Province/State: _____ Country: _____

Municipality/County: _____ Town/City _____

Indicate surrounding zones where there also are measles outbreaks _____

Date of rash onset of the first case: _____/_____/_____

Date of rash onset of the last case: _____/_____/_____

**NUMBER OF CASES BY AGE IN YEARS**

| | <1 | 1 | 2 | 3 | 4 | 5–9 | 10–14 | >15 | TOTALS |
|---|---|---|---|---|---|---|---|---|---|
| Suspected | | | | | | | | | |
| Confirmed | | | | | | | | | |

**VACCINATION HISTORY OF THE CASES**

| AGE (years) | CONFIRMED MEASLES CASES | | | | | |
|---|---|---|---|---|---|---|
| | Non-vaccinated | Documented vaccination history 1 | 2 | 3 | Unknown | Total |
| <1 | | | | | | |
| 1–2 | | | | | | |
| 3–4 | | | | | | |
| 5–9 | | | | | | |
| 10–14 | | | | | | |
| 15+ | | | | | | |
| TOTALS | | | | | | |

**LOCALITY COVERAGE**

| AGE (years) | More than one dose % |
|---|---|
| <1 | |
| 1–2 | |
| 3–4 | |
| 5–9 | |
| 10–14 | |
| 15+ | |
| TOTALS | |

| VACCINATION FOR OUTBREAK CONTROL | | | <1 year | 1–4 years | >5 years | TOTAL |
|---|---|---|---|---|---|---|
| Start date | ___/___/___ | No. of vaccines administered: | | | | |
| End date | ___/___/___ | No. of visited homes: | | | | |

**INDICATED TOWNS OR CITIES VISITED DURING THE INVESTIGATION**

| Name | Date | No. of persons vaccinated | Comments (Cases found?) |
|---|---|---|---|
| _____ | ___/___/_____ | _____ | _____ |
| _____ | ___/___/_____ | _____ | _____ |
| _____ | ___/___/_____ | _____ | _____ |
| _____ | ___/___/_____ | _____ | _____ |

Describe control activities:

Describe follow-up activities:

Investigator name: Date: ___/___/_____

Place:

**Pan American Health Organization**

*Regional Office of the*
World Health Organization
525 Twenty-third Street, NW
Washington, DC 20037 USA
www.paho.org

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