REVIEW ARTICLE

Measles 2025

Lien Anh Ha Do, M.D., Ph.D.,[1,2] and Kim Mulholland, M.B., B.S., M.D.[1-4]

Author affiliations are listed at the end of the article. Dr. Do can be contacted at lienanhha.do@mcri.edu.au or at Murdoch Children's Research Institute, 50 Flemington Rd., Melbourne, VIC 3052, Australia.

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CME

Measles is a highly contagious virus with a primary case reproduction number (i.e., the average number of secondary cases per case patient) of 12 to 18. It is currently spreading rapidly owing to reduced measles vaccination coverage, which is due primarily to the disruption of local immunization programs by the coronavirus disease 2019 (Covid-19) pandemic and of growing vaccine hesitancy.[1] Since 2024, all World Health Organization (WHO) regions have reported increased numbers of measles cases, with 395,521 laboratory-confirmed measles cases reported in 2024 and 16,147 reported during the first 2 months of 2025.[2] Patients in more than half the reported cases were hospitalized, so the true number is probably much higher.[3]

This review covers clinical presentations and complications of measles, current recommendations, and the epidemiologic background of measles. It also addresses the current debates on immunization and the treatment of measles and presents information on the origins of the various measles vaccines and updates on measles diagnostic testing and molecular genotypes.

CLINICAL PRESENTATIONS AND COMPLICATIONS

CLASSIC MEASLES SYNDROME

Between 10 and 14 days (range, 7 to 23) after exposure, illness starts with a prodromal phase that includes fever and any of three symptoms — cough, coryza, and conjunctivitis (the "three Cs"). The prodromal phase lasts for 2 to 4 days. Koplik spots, small white spots on the buccal mucosa, are pathognomonic for measles but are not always present (Fig. 1A). The spots may appear 1 to 2 days before the onset of rash and last for an additional 1 to 2 days after rash onset. A typical measles rash is an erythematous maculopapular exanthem that appears 2 to 4 days after the onset of fever, starting with the face and proceeding to the head, trunk, arms, and legs Fig. 1B. Persons with the infection typically can transmit the virus 4 days before and 4 days after the eruption of the rash (Fig. 1D). Diarrhea can appear early in the acute phase and may last for a month.[4] Prodromal symptoms, rash, and diarrhea in any child should arouse suspicion for measles infection.

Because measles is a systemic infection, it can affect the skin, eyes, gut, and respiratory system. Complications that occur in approximately 30% of measles cases[4] — and frequently occur up to 1 month after infection — include diarrhea, pneumonia, otitis media, and conjunctivitis (Table 1 and Fig. 1C).[5-14] Pneumonitis and giant-cell pneumonia are rare but severe and potentially fatal complications of measles. These conditions are reported mainly in persons who are immunosuppressed and in young children.

Even after recovery, children who have had measles are at high risk for late complications such as pneumonia, malnutrition, and blindness. Blindness is usually due to severe corneal ulceration, and sometimes corneal perforation, in children who are deficient in vitamin A.[4] Temporary immune amnesia caused by depletion of B-cell and T-cell memory by the measles virus has recently been shown

KEY POINTS

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- Measles causes a range of serious health issues, including immune amnesia that may last up to 1 year in fully recovered patients and increased susceptibility to sometimes severe secondary infections. Research on restoring immunity more rapidly is needed.
- Measles vaccine has a long safety history and is highly effective against all circulating measles genotypes.
- Measles is highly contagious; therefore, a high coverage level (>95%) of both recommended doses of measles vaccine is necessary to prevent community transmission.
- Vitamin A supplementation is recommended for all persons who have measles to reduce complications and the risk of death, particularly in persons who have deficient levels of vitamin A, such as persons living in low- and middle-income countries. Vitamin A does not prevent measles infection. More data are needed regarding the benefits of vitamin A in persons living in developed countries who have measles.
- Waning levels of maternal measles antibodies at 3 to 4 months of age has increased measles risk in young infants. Further research on the effectiveness of early measles vaccination is needed.
- Additional randomized, controlled trials are needed to evaluate the clinical efficacy of vaccine microneedle patches, which may help to increase vaccination coverage.

to be a mechanism for longer-term susceptibility to secondary infections in persons who have had measles (see the Supplementary Appendix, available with the full text of this article at NEJM.org). Children recovering from measles are at elevated relative risk for serious secondary infection, particularly pneumonia. Even in a high-resource area of Germany, the risk of pneumonia among children with measles was elevated as compared with that among children who had noninfectious diseases (risk ratio, 1.6; 95% confidence interval [CI], 1.4 to 2.0).[15] In low- and middle-income countries, the risk is greater than in countries with higher incomes, and measles is associated with substantial mortality.[16]

Measles-associated encephalitis is a rare but serious, and potentially fatal, complication. It can occur during the first 7 days of infection (acute postinfectious measles encephalitis), 1 to 6 months after infection (measles-inclusion body encephalitis), or even years after full recovery (subacute sclerosing panencephalitis).[14]

ATYPICAL MEASLES SYNDROME

Atypical measles syndrome was first reported in the 1960s among children who received the inactivated (killed) measles vaccine that was in use during the period 1963–1967. After these children were exposed to measles virus in the community, they became ill with a severe form of measles disease marked by high fever, an unusual type of rash (a petechial or morbilliform rash that began on the arms and legs), and severe pneumonia.[17] This atypical measles syndrome has been reported rarely since the inactivated measles vaccine was withdrawn in 1967.[14]

MODIFIED MEASLES SYNDROME

Measles can occur in persons who are fully vaccinated (i.e., have received two doses) or who are undervaccinated. These breakthrough infections can result from primary vaccine failure, lack of seroconversion after immunization, or secondary vaccine failure due to waning of the measles-antibody level (waning immunity), which can occur 6 or more years after vaccination.[18]

Persons with primary vaccine failure may have the classic measles syndrome, but persons with secondary vaccine failure tend to have milder symptoms — often only a rash with little or no fever, nonspecific respiratory symptoms, and a lower viral load. Persons with secondary vaccine failure are at lower risk for transmission than unvaccinated persons who have measles infection.[18]

MEASLES IN SPECIAL POPULATIONS

When measles outbreaks occur, persons with compromised immunity, such as malnourished children, immunocompromised persons (e.g., persons who have human immunodeficiency virus [HIV] or are receiving cancer treatment), and

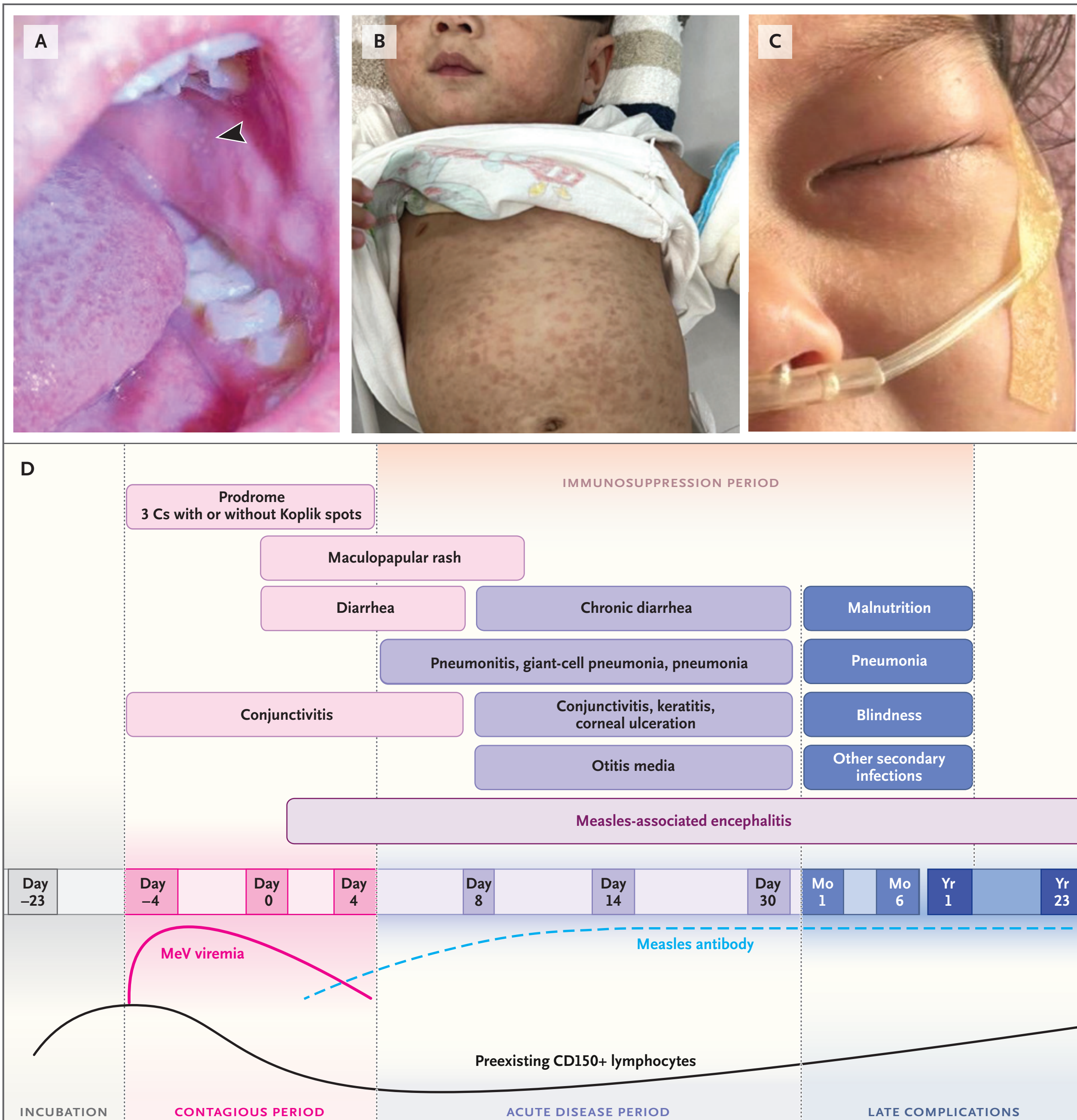

Figure 1. Clinical Features and Pathogenesis of Measles.

Features of measles include Koplik spots on the buccal mucosa (Panel A); rash on the trunk, spreading to the face, head, arms, and legs (Panel B); and conjunctivitis (Panel C). Day 0 denotes the day the measles rash appears; Day −4 is the probable start of infectiousness, Day 4 is the probable end of infectiousness, and Day −23 is the earliest possible exposure day (Panel D). CD150+ lymphocytes are T and B memory lymphocytes targeted by the measles virus. 3 Cs denotes cough, coryza, and conjunctivitis, and MeV measles virus. Images in Panels A, B, and C were provided by Du Tuan Quy, M.D., with the approval of Le Nguyen Thanh Nhan, M.D., Ph.D., Children's Hospital 1, Ho Chi Minh City, Vietnam.

Table 1. Incidence of Severe Complications Associated with Measles.

Complications	Incidence in Developed Countries	Comments
Pneumonia	1–6 per 100 measles cases[5]	Among the most common complications during the first month of measles; most common cause of measles hospitalization
Diarrhea	8–10 per 100 measles cases[5]	Common complication during the first month of measles
Keratitis or keratoconjunctivitis	3–10 per 100 measles cases [6-9]	Keratoconjunctivitis may appear in the prodromal stages of measles and persist for as long as 3 months[6]; keratitis with retinitis and optic neuritis also has been reported.[7-9]
Corneal ulceration	Rare	Documented in 1–4 per 100 measles cases in the 1980s in Africa and South Asia[10,11]; measles can cause corneal ulceration directly and facilitate a secondary infection (such as herpes simplex keratitis) that leads to corneal ulceration[10,11]
Blindness	Rare	Measles is a leading cause of childhood blindness in places where measles is endemic; results of surveys conducted in schools in Africa in the 1970s suggested that measles was the cause of 33 to 79% cases of blindness.[11]
Otitis media	7–9 per 100 measles cases[5]	One of the most common complications during the first month of measles; can lead to sensorineural deafness, which was observed in 5 to 10% of measles cases in the United States before the introduction of measles vaccination programs[5]
Death	1–3 per 1000 measles cases[5]	16 per 1000 measles cases in low-income countries[12]; 9 per 1000 measles cases in middle-income countries[12]; up to 180 per 1000 measles cases reported in the context of humanitarian relief efforts during major outbreaks[13]
Malnutrition	8–10 per 100 measles cases	
Acute postinfectious measles encephalitis	1 per 1000 measles cases[14]	Develops within the first week of measles, after the appearance of the first symptoms, and is associated with 20% mortality[14]
Measles-inclusion body encephalitis	1 per 1000 measles cases[14]	Develops within 7 days to 6 months after onset of measles and is associated with 100% mortality[14]
Subacute sclerosing panencephalitis	7–11 per 100,000 measles cases[5,14]	Develops within 7–10 years after measles and is associated with 100% mortality within 1–3 years after onset[14]; young children with measles (<2 years of age) are at increased risk

pregnant persons are particularly vulnerable. Persons with HIV who are not immune to measles are at increased risk for more severe measles infection with pneumonia or encephalitis.

In a series of 23 pediatric cancer patients in China who had measles infection, 5 underwent ventilation, 1 had liver failure, and 4 died. These outcomes occurred even though 20 of the 23 patients had been vaccinated (including the 4 who died) and 21 had been treated with intravenous immune globulin.[19]

Malnutrition and measles have a historical link, particularly in the context of humanitarian relief efforts. The bidirectional relationship between measles and malnutrition was described decades ago.[20] Malnutrition is a primary contributor to death in 45% of fatal measles cases.[21] Measles is worse in children who are already malnourished, and postmeasles effects can lead to malnutrition in children who were not malnourished before they were infected with measles.[13] Measles can lead to or exacerbate vitamin A deficiency[22] or a persistent nutritional deficit.[23] Malnourished children have a poor response to measles vaccine and other vaccines.[24,25]

Although measles virus is not teratogenic, measles in pregnant persons can lead to fetal loss, intrauterine growth retardation, and premature delivery.[26] The case fatality rate among pregnant persons with measles can range from 5% in areas where measles is endemic, such as in Asia and in sub-Saharan Africa, to 20 to 30% among fragile populations, such as refugee populations.[27] Preterm birth is reported as the most frequent fetal complication.[26]

CURRENT RECOMMENDATIONS

CURRENT GLOBAL PEDIATRIC MEASLES VACCINATION POLICY

Measles vaccine has a long history. Various attenuated measles vaccine strains were developed

Table 2. Summary of Current Measles Vaccination Recommendations in the United States.*

Recommendation	Schedule and Dose
Preschool children	
Routine childhood schedule	Two-dose schedule — First dose at 12 to 15 months of age (MMR vaccine), second dose at 4 to 6 years of age (MMR-V vaccine)
In outbreak locations or before international travel	Additional dose is given as early as 6 months of age to all children younger than 12 months of age; routine two-dose schedule is still recommended, but earlier second dose is recommended†
Healthy adults	Two-dose schedule unless evidence of immunity; no booster program for those with evidence of previous vaccination on two-dose schedule‡
Special populations	
Health care workers born before 1957	One or two doses of measles vaccine unless evidence of immunity‡
Health care workers born in 1957 or later	Two-dose schedule unless evidence of immunity†‡
Received measles vaccine between 1967 and 1989	One or two doses of measles vaccine unless evidence of immunity‡
≥12 mo of age with HIV infection	Two-dose schedule: first dose at 12 months of age (MMR vaccine), second dose can be earlier than routine (at 13 months of age; MMR vaccine)†§
International travelers	Two-dose schedule unless evidence of immunity†‡
Family carers of immunocompromised patients	Two-dose schedule unless evidence of immunity†‡

* Adapted from Centers for Disease Control and Prevention recommendations, available at https://www.cdc.gov/vaccines/vpd/mmr/hcp/recommendations.html. HIV denotes human immunodeficiency virus, MMR measles–mumps–rubella, and MMR-V measles–mumps–rubella–varicella.

† A 28-day period between the doses is recommended.

‡ Evidence of immunity includes written documentation of one or more doses of measles vaccine administered on or after the first birthday for preschool-age children and adults not considered high risk; written documentation of two doses of measles vaccine for school-age children and adults at high risk, including students at post–high school secondary educational institutions, health care personnel, and international travelers; laboratory evidence of immunity; laboratory confirmation of disease; and birth before 1957 (except in health care workers born before 1957, for whom the evidence of immunity is laboratory evidence of immunity or laboratory confirmation of disease).

§ MMR vaccine is indicated only in the absence of severe immunosuppression, which is defined as a CD4 percentage of less than 15% for at least 6 months in persons 5 years of age or younger and a CD4 percentage of less than 15% and CD4 count of less than 200 lymphocytes per cubic millimeter for at least 6 months for persons 5 years of age or older. MMR-V is contraindicated in persons with HIV infection; only MMR vaccine is approved for use in such patients.

and are in active use worldwide (see the Supplementary Appendix) either as a monovalent vaccine or combined with mumps and rubella vaccines, with or without varicella vaccine.

The recommended age for the first dose of measles-containing vaccine depends on the waning of maternal antibodies in the patient and the risk of measles exposure.[4] In countries where measles is in elimination status (i.e., continuous transmission has been absent for more than 12 months), the first dose may be given at 12 to 18 months of age for maximum immunogenicity, although this schedule leaves most infants in the country susceptible to infection. In countries where measles is endemic — mainly low- and middle-income countries — the first dose of measles vaccine is usually given at 9 months of age. China and South Africa are exceptions, with the routine first dose given at 8 months and 6 months of age, respectively.[2] Given that 10 to 15% of infants who receive the first dose at 9 months of age do not have seroconversion and to ensure protection for children who either do not have a response to the first dose or miss the first dose entirely, the WHO recommends a second dose for all children globally.[4] The recommended shortest time between the two doses is 4 weeks. The timing of the first and second doses of measles vaccine in each country depends on the epidemiologic context and the recommendations of the immunization program of the country. The WHO also recommends an additional dose for infants 6 to 11 months of age during measles outbreaks in regions where measles is endemic.[4]

In the United States, the first dose is given at 12 to 15 months of age and the second dose at 4 to 6 years. Infants 6 to 11 months of age may also be given an additional dose in regions where there are outbreaks or before international travel (Table 2).[28]

Because the measles virus has a high reproduction number, high coverage of both doses of measles vaccine (≥95%) at the population level is required to maintain effective herd immunity against measles transmission.[29] In reality, this goal is a very difficult one to attain for most countries owing to growing global vaccine hesitancy and other challenges, such as financial barriers, poor access to health care, and inappropriate contraindications in certain cases. Even when high vaccination coverage is achieved, small, poorly vaccinated communities may still have outbreaks.[30,31]

POSTEXPOSURE PROPHYLAXIS

In unvaccinated or undervaccinated persons, measles vaccine is recommended within 72 hours after exposure. When there are contraindications to the measles vaccine, such as in immunocompromised or pregnant persons or infants younger than 6 months of age, human immune globulin is recommended to be given within 6 days after exposure.[4]

Recommendations for postexposure prophylaxis and the availability of immune globulin products vary among countries.[32] In many low- and middle-income countries, access to immune globulin is very limited owing to its high cost and low availability.

A recent meta-analysis showed that the estimated effectiveness of postexposure prophylaxis for the prevention of measles ranged from 76% (95% CI, 0 to 94) to 100% (95% CI, 56 to 100) with immune globulin and from 83% (95% CI, 34 to 96) to 100% (95% CI, not evaluable) with the measles vaccine.[33] Postexposure prophylaxis with immune globulin offers greater short-term protection than postexposure prophylaxis with the measles vaccine but at greater cost and use of resources.

The effectiveness of postexposure prophylaxis may be affected by the concentration of measles antibodies in immune globulin products,[34] the nature and intensity of measles exposure events, and the timing of postexposure prophylaxis.[35] The timing of postexposure prophylaxis reported in the studies included in the meta-analysis was recommended mainly on the basis of the duration of measles incubation; there are very limited data on the effect of delayed postexposure prophylaxis.[33,36]

Because levels of measles antibodies in the immune globulin donor population have decreased over time,[37] measles antibody concentration in immune globulin products is also decreasing. This change highlights the need for periodic review of the recommended dose.[38,39] Although the correlates of protection for measles have been recently debated,[40] the previously published threshold (i.e., >120 mIU per milliliter) has been widely accepted and used as the target serum concentration for measles antibodies after postexposure passive immunization, thereby guiding the recommended dose.[38,39]

MANAGEMENT OF MEASLES

There is no approved antiviral medication for measles. Management of measles infection involves early detection and treatment of complications as well as patient isolation to prevent nosocomial and community transmission.

Vitamin A deficiency has been associated with measles severity and mortality among children in low- and middle-income countries. In large-scale, community-based, randomized trials in many Asian and African countries between 1983 and 1992, administration of vitamin A reduced measles mortality by 34 to 50% among children 1 to 5 years of age in low- and middle-income countries.[41] Vitamin A deficiency (serum retinol level, <10 μg per deciliter) is a major public health issue affecting preschool-age children in low- and middle-income countries.[41] Since 1993, the WHO has recommended vitamin A, with specific doses according to age groups, to all persons who have acute measles infection, irrespective of the timing of previous doses of vitamin A (Table 3).[4] This recommendation is based on data from studies conducted in low- and middle-income countries,[43] and there has been no report of toxic effects from vitamin A in patients with measles who have received vitamin A according to WHO recommendations.[41,43] The benefit of routine vitamin A supplementation outside of treating measles or other specific diseases remains debated, particularly when the vitamin A–deficiency status is unknown.[44] In addition, routine vitamin A supplementation in excess of the recommended dietary allowance can cause acute and chronic toxic effects in well-nourished children and adults.[45]

Children are particularly sensitive; daily intakes of more than 1500 IU per kilogram of body weight have been associated with toxic effects in children.[45]

In the only known study of the use of vitamin A in measles management in the United States, only 39% of patients received vitamin A and received a much lower dose than that recommended by the WHO.[41] In contrast, recent cases of toxic effects of vitamin A intake associated with measles outbreaks in the United States (notably in West Texas) were linked to excessive or unsupervised intake of vitamin A outside medical guidance owing to misinformation. These data point to a need for clarity regarding vitamin A supplementation in the treatment of measles to inform health care workers and the public in the United States.

Data are limited regarding the benefit of vitamin A in the context of the United States, where vitamin A deficiency is rare. Measles depresses serum levels of vitamin A in well-nourished children to below the levels observed in malnourished children without measles.[46] In the United States, hospitalized children with measles frequently have low serum vitamin A levels, correlating with measles severity.[41] Because vitamin A is critical in enhancing immune responses against infections,[41] supplementation with vitamin A is recommended in children with measles. A meeting on the subject led by the National Foundation for Infectious Diseases in November 2019 provided suggestions on vitamin A doses (Table 3).

Table 3. **U.S. Recommendations for Vitamin A Supplementation in Patients with Measles.***

Age Group	Dose	Frequency
Children		
<6 mo	50,000 IU (15,000 μg RAE)	Daily for 2 days
6–11 mo	100,000 IU (30,000 μg RAE)	Daily for 2 days
>12 mo	200,000 IU (60,000 μg RAE)	Daily for 2 days
Previous vitamin A deficiency or eye complications caused by measles	Third dose	2–4 wk after the second dose
Adults†	No recommendation	No recommendation

* Adapted from Stinchfield PA and Orenstein WA.[41] IU denotes international unit, and RAE retinol activity equivalents.

† The U.S. recommendation aligns with the World Health Organization (WHO) recommendation.[42] However, the WHO recommends a dose of 5000 to 10,000 IU daily for 4 weeks in adult measles patients. Women of reproductive age should receive only lower, but more frequent, doses of vitamin A (e.g., a daily oral dose of 5000 to 10,000 IU of vitamin A for at least 4 weeks) owing to possible teratogenic effects.

CURRENT MEASLES EPIDEMIOLOGIC BACKGROUND

IMMUNITY GAPS IN YOUNG INFANTS AND EARLY MEASLES VACCINATION

Recent data have shown that the rate of decline of maternal antibodies has increased over time both in regions where measles is endemic and in areas where measles has been eliminated.[47,48] In Canada in the period 2014–2016, more than 90% of 3-month-old infants had levels of maternal measles antibodies that were lower than a threshold neutralization titer of 192 mIU per milliliter.[49] A recent multicountry modeling exercise predicted 70.8%, 88.3%, and 100% of infants would be seronegative by 2, 4, and 6 months of age, respectively.[50] A meta-analysis of data from low- and middle-income countries (2018–2024) showed that by 4 months of age, only 24 to 35% of children remained seropositive.[51] Clearly, many unvaccinated young infants in regions of measles outbreaks are at high risk for acquiring measles.

In 2023 and 2024, more than 90% of the measles cases worldwide were among children in low- and middle-income countries.[29] Most of those infected were children younger than 5 years of age, with the highest mortality among those younger than 1 year.[12] No systematic analysis has been conducted over the past decade to confirm the observed trend of increasing proportions of measles cases and deaths among young infants. Vietnam, which was among the top 10 countries in terms of number of measles cases in March 2025, had reported a rising number of cases among children 6 to 8 months of age; that age group represented 25% of measles cases in some areas.[52] Young infants are at heightened risk for severe measles-related complications such as pneumonia, encephalitis, and death.[53,54] Children in this group are also at increased risk for subacute sclerosing panencephalitis, a rare but fatal condition.[55,56]

In recognition of the potential vulnerability of young infants, discussions on the timing of the first dose of measles vaccine have been under way for decades and more recently at the WHO.[4,57-60] An early dose of measles vaccine given at 3 to 4 months of age could provide protection throughout infancy. Three studies conducted more than a decade ago provided some data regarding the safety, efficacy, and potential blunting effect (i.e., reducing the immunogenicity, both short term and long term, of subsequent doses) of an early dose of measles vaccine given at 4 to 4.5 months of age.[61-63] This dose could be either the early administration of the first recommended dose of the vaccine or an additional dose to the current two-dose schedule.[61-63] Both approaches have shown acceptable safety and immunogenicity.[61,62] The first dose, when given at 4.5 months of age, provided 94% efficacy against measles infection and 100% efficacy against hospitalization for measles.[62] Determining the appropriate timing of an early dose requires a balance between the age-stratified infection risk (the age at which maternal antibodies would no longer inhibit measles vaccine immunogenicity) and the duration of vaccine effectiveness over time.[57,58] A trade-off of administering an early dose is the reportedly more rapid reduction of measles antibody in children who are vaccinated early in infancy.[64,65] Whether this antibody reduction would translate to reduced vaccine efficacy in later childhood is still an open question.

IMMUNITY GAPS IN ADULTS AND BOOSTER DOSE

Because the two-dose measles vaccine schedule was not introduced in the United States until 1989, persons who received the vaccine between 1967 and 1989 may consider receiving a second dose if they are in a high-risk group, such as health care workers or international travelers.[28] An extra dose of measles vaccine may be also considered in persons who received the vaccine between 1963 and 1967, because the inactivated (killed) vaccine that was used was less effective than the current live attenuated vaccine.[28] Of note, persons who received measles vaccine between 1967 and 1989 or who received the inactivated measles vaccine may have immunity that is "boosted" over time by natural measles exposure, because measles was still endemic in the United States until 2000.

Among persons born before 1957 (before the first measles vaccine was licensed in 1963), natural measles immunity is even more certain because measles cases were common until that time. However, measles vaccine should still be considered in health care workers who do not have laboratory evidence of immunity or laboratory confirmation of disease. Currently, there is no recommended routine catch-up vaccination program for adults in the United States.[28]

The primary cause of the resurgence in measles cases is failure to vaccinate, not failure of the vaccine. Neither the Centers for Disease Control and Prevention nor the WHO recommend routine boosters in persons who are fully vaccinated. Studies regarding serologic events conducted in the past 5 years in areas where measles is endemic and in ones where measles has been eliminated have reported immunity gaps in persons who received the vaccine on the two-dose schedule during childhood.[48,66,67] Most of these persons are 13 to 30 years of age, with some older than 40 years of age. Adults who have likely secondary vaccine failure account for some of the measles cases in outbreaks in well-vaccinated countries, as was the case recently in Mongolia.[68] A third dose of measles vaccine has been offered, mainly to health care workers, with similar safety and rates of adverse events as those seen with the recommended two doses. However, high antibody levels induced by the third dose waned quickly over a period of 1 to 3 years after the third dose.[69]

2019 INCREASE IN MEASLES CASES AND ONGOING 2024–2025 MEASLES CRISIS

Worldwide, reported measles cases saw a dramatic increase in recent years, from a historic low of 132,490 in 2016 to 869,770 in 2019.[70] The global increase in measles cases in 2019 was driven by large outbreaks in several countries. The Democratic Republic of the Congo, Madagascar, Samoa, Ukraine, and Brazil were the countries most affected. Vaccine hesitancy was an important cause in each of the affected countries.[70] This factor also contributed to the more than 100,000 measles cases in Europe in 2019 and the increased number of measles cases in the United States almost 20 years after the declaration that the disease had been eliminated in 2000.[71] In 2019, vaccine hesitancy was recognized by the WHO as one of the top 10 challenges to global health.[1] Since 2019, no WHO region has achieved and sustained elimination of measles.

The Covid-19 pandemic worsened the situation by interrupting routine immunization and catch-up campaigns. During the pandemic, global coverage of first measles vaccines decreased to 81%, the lowest level since 2008. Coverage has improved slightly, to 83% in 2022 and 2023.[29] Low- and middle-income countries have the lowest coverage of first measles vaccines — 64% in low-income countries and 86% in middle-income countries.[29] A recent analysis of county-level rates of measles–mumps–rubella (MMR) vaccinations in 37 U.S. states shows that coverage was below 95% in 990 of 1501 counties and below 74% in 70 counties.[72]

This poor coverage has sparked large measles outbreaks in several countries since early 2024, and measles is now spreading widely. In 2024, the European region reported the highest number of measles cases in more than 25 years, accounting for 20% of the total measles cases worldwide.[2] In the United States, as of May 30, 2025, 1088 confirmed measles cases and 3 deaths have been reported; 96% of those measles cases involved persons who were unvaccinated or whose vaccination status was unknown. In approximately 12% of reported cases, the infected persons were hospitalized.[73] The current number of cases is already approximately four times as high as the total reported in 2024. If measles outbreaks continue to spread through the United States for more than 12 months, the country will lose its elimination status.

Misinformation suggesting that measles vaccine causes autism and that vitamin A prevents measles has been a serious threat to effective measles control and management in the United States and worldwide. More than 25 years ago, a campaign of misinformation suggesting that measles vaccine causes autism led to loss of confidence in MMR vaccines, especially in the United Kingdom.[74] This misinformation has been thoroughly investigated and proved to be incorrect. In the United States, the recent decrease in childhood vaccinations has been associated with vaccine hesitancy. Estimates suggest that a 10% decrease in MMR vaccination in the United States may lead to 11.1 million measles cases over a period of 25 years.[75]

The withdrawal of the United States from global public health initiatives and from support of global immunization programs is having a profound effect on measles control worldwide. Specifically, removal of support for the WHO, for which the United States contributes 19% of the budget, and Gavi, the Vaccine Alliance, for which it contributes 13% of the budget, will probably affect measles control and contribute to a large number of deaths from measles and other vaccine-preventable diseases in the poorest countries.[76] As a result, the outlook for measles control in the coming years is bleak. This situation puts U.S. domestic health security at high risk, because infectious diseases do not respect geographic borders.

In the context of increased international travel, rapid identification of measles cases and genotyping of measles virus are crucial for early detection of outbreaks, tracking of transmission chains, and effective outbreak control. Updates on measles diagnostic and molecular genotypes are provided in the Supplementary Appendix.

CONCLUSIONS AND PERSPECTIVES

There has been little improvement in global measles control over the past two decades. With a declining environment for global health (Fig. 2), it is possible that the situation will get worse. Estimates of measles morbidity and mortality associated with vaccine hesitancy are needed to help contain vaccine hesitancy. Enhanced research during measles outbreaks is crucial to address population immunity gaps and improve vaccine coverage in the current measles vaccination program. Rapid diagnostic tests could be used routinely as part of measles global surveillance and could improve the timing of measles outbreak responses.[77]

Postmeasles pneumonia has been shown to be largely due to *Streptococcus pneumoniae*. The use of a booster dose of pneumococcal conjugate vaccine for patients recovering from measles to help overcome temporary immunologic amnesia and possibly prevent fatal postmeasles pneumonia is a potential strategy. Clinical trials are needed to determine the appropriate time to administer pneumococcal conjugate vaccine during measles recovery.

Measles disease is most severe in young infants. Studies from West Africa have shown that measles vaccine can be highly effective, even when it is given as early as 4 months of age.[62] This finding needs to be reevaluated in the modern era.

Efforts have been made to improve vaccine

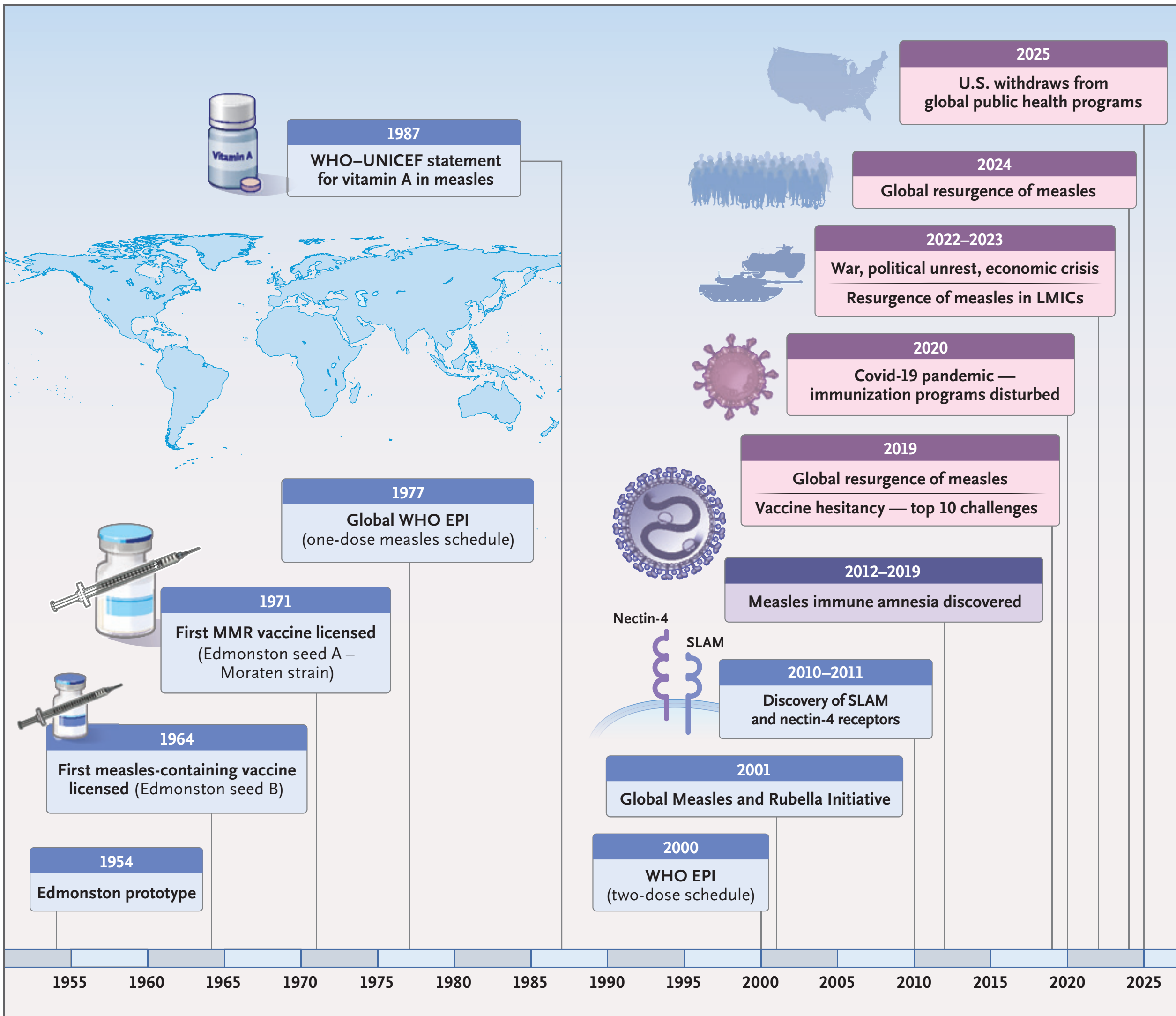

Figure 2. Key Events in Measles Research.

Covid-19 denotes coronavirus disease 2019, EPI Expanded Programme on Immunization, LMICs low- and middle-income countries, MMR measles–mumps–rubella, SLAM signaling lymphocytic activation molecule, UNICEF United Nations Children's Fund, and WHO World Health Organization.

delivery[78] and storage.[79] Microneedle patches have been developed that offer the possibility of providing vaccination against measles and other conditions in remote areas where cold-chain transport is difficult. Microneedle patches also provide a pain-free, simplified method of vaccine administration. This innovation may help to improve vaccination coverage and reduce cold-chain issues. Additional randomized, controlled trials are needed to evaluate the efficacy of microneedle patches. In addition, further research on new measles vaccine candidates that can be given to younger infants is needed, because such vaccines may be required for eradication of measles.[80]

Disclosure forms provided by the authors are available with the full text of this article at NEJM.org.

AUTHOR INFORMATION

[1] Murdoch Children's Research Institute, Melbourne, VIC, Australia; [2] Department of Paediatrics, University of Melbourne, Melbourne, VIC, Australia; [3] London School of Hygiene and Tropical Medicine, London; [4] University of Nagasaki, Nagasaki, Japan.

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