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Comprehensive Review of Measles: Latest Outbreak Trends, Clinical Manifestations, and Therapeutic Approaches

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ABSTRACT

Measles continues to pose a major global health challenge despite the availability of safe and effective vaccines. Caused by the measles virus, an RNA virus of the paramyxoviridae family, it spreads via respiratory droplets and is among the most contagious infectious diseases, with a basic reproduction number (R_0) of 12–18. The disease typically begins with a prodromal phase characterized by fever, cough, coryza, and conjunctivitis, followed by the hallmark maculopapular rash. Complications such as pneumonia, encephalitis, and subacute sclerosing panencephalitis (SSPE) significantly contribute to measles-related morbidity and mortality, particularly in young children and immunocompromised individuals. The introduction of the measles-containing vaccine (MCV), often administered as part of the measles-mumps-rubella (MMR) combination, has drastically reduced global incidence. However, recent resurgences, even in high-income countries, underscore persistent challenges such as vaccine hesitancy, misinformation, and logistical barriers to vaccination. The World Health Organization (WHO) has spearheaded measles elimination programs through mass immunization campaigns, outbreak response efforts, and global health policy initiatives. Nevertheless, measles remains endemic in several regions, especially where healthcare infrastructure is weak, conflict disrupts routine immunization, or public trust in vaccines is low. Emerging research has also drawn attention to measles-induced “immune amnesia,” wherein the virus depletes established immune memory, increasing vulnerability to other infections. Achieving global measles elimination demands a coordinated and sustained approach involving policy enforcement, strengthened immunization systems, effective public health communication, and community engagement. This article underscores the latest updates regarding measles in terms of epidemiology, treatment and management as well as the need for renewed efforts in combating measles to achieve the WHO’s goal of global measles elimination.

Keywords: Measles; vaccination strategies; treatment; management; eradication

1. INTRODUCTION

The measles virus is an RNA virus that belongs to the *Paramyxoviridae* family and causes measles, often referred to as rubeola, which is an acute febrile disease that is extremely infectious. Since it spreads rapidly among individuals in close proximity, especially in crowded environments, it presents a significant hazard to public health. [1,2] Initially, symptoms of measles and other eruptive fevers, including smallpox, are similar, which often leads to confusion. The Persian physician Rhazes made the first precise differentiation between smallpox and measles. Measles outbreaks in Europe have been recorded since the eleventh and twelfth centuries. Significant health impacts were caused by larger and more widespread epidemics documented in the 17th century.[3] Measles can affect individuals of any age; however, it is most commonly seen in young children. Before the measles vaccine was developed in 1963 and vaccination campaigns became widespread, the illness led to substantial outbreaks approximately every two to three years. With approximately 2.6 million fatalities annually, primarily among young children, these diseases had devastating effects. Measles spreads rapidly throughout communities due to its high contagiousness, particularly in areas with little or no vaccine coverage. [4]

Despite the creation of a vaccine that is safe, extremely efficient, and affordable, as well as remarkable advancements in medical research, measles continues to pose a serious threat to public health. A projected 107,500 people died of the disease in 2023 alone, with children under the age of five accounting for the great bulk of deaths. These concerning numbers highlight the ongoing difficulties in international vaccination campaigns and the pressing need for more vaccine accessibility, knowledge, and coverage to stop needless deaths and eradicate measles as a public health issue.[4]

The goal of this comprehensive study is to provide an in-depth overview of measles, focusing on current epidemic patterns, clinical signs, and treatment strategies. Despite significant progress in vaccination campaigns, measles remains a major global health concern, particularly in regions with low vaccination rates. This study also explores the clinical spectrum of measles, ranging from mild symptoms to severe complications, while evaluating the effectiveness of modern therapeutic methods alongside supportive care. In addition to discussing current treatment strategies, such as supportive care and complication management, it underscores the need for stronger vaccination campaigns and public health policies to control and ultimately eradicate measles.

2. Epidemiology and Transmission

Despite efforts to eradicate it, measles remains a worldwide health concern, with outbreaks difficult to contain in different places. Although all six of the World Health Organization's (WHO) regional commitments are to eliminate measles, not one has ever been able to do this consistently and successfully. Global coverage of the first dose of the measles-containing vaccine (MCV) rose from 72% to 86% between 2000 and 2019, but by 2021, it had fallen to 81%. The number of nations suffering major or disruptive outbreaks grew from 22 to 37 during 2021–2022, while the expected number of instances of measles climbed by 18%, from 7,802,000 to 9,232,300. During the same period, measles-related mortality also increased dramatically, rising from 95,000 to 136,200, a 43% increase.[5] Instances of measles have been reported to have increased in Madagascar, Ukraine, India, Brazil, the Philippines, Venezuela, Thailand, Kazakhstan, Nigeria, and Pakistan. The anticipated global measles case count increased by 20% between 2022 and 2023, from 8,645,000 to 10,341,000. Furthermore, the count of nations experiencing substantial or disruptive epidemics rose from 36 to 57. Measles-related mortality decreased by 8% from 116,800 in 2022 to 107,500 in 2023, despite this increase in incidence.[6]

The primary way the measles virus spreads is through respiratory droplets and tiny aerosol particles, which are inhaled through the breath of an infected person or via contact with contaminated nasal or throat secretions, including those emitted during coughing or sneezing.[6] The virus primarily targets lymphocytes and, within two days, infects the dendritic cells and alveolar macrophages in the lungs. The illness begins in the lower respiratory tract and subsequently spreads to the upper tract. Viral transmission is aided by the severe cough and coryza. Outbreaks typically occur in late winter and early spring, as the endemic measles virus shows a distinct seasonal pattern of transmission. Both environmental factors that promote viral spread in temperate climates and social contact patterns, particularly the increased interaction among schoolchildren, influence these periodic surges.[7]

Several serious health issues can arise from measles. The most common cause of measles-related mortality is pneumonia with bacterial superinfections, a respiratory condition. Otitis media can lead to hearing loss. Malnutrition may be caused or worsened by digestive issues such as stomatitis and diarrhea, increasing the risk of various health complications. Measles keratoconjunctivitis can also result in blindness, particularly in children who are vitamin A deficient. Additionally, the illness may cause seizures, with or without a temperature, 3–6 days after the rash, acute encephalitis (1 in 1000), and preterm births.[8]

3. Clinical Manifestations

Pregnant women, undernourished or immunocompromised children, and newborns are the groups most likely to experience measles complications. [9] Fever, cough, coryza, and conjunctivitis are the prodromal symptoms of clinically evident measles. Before the rash develops, Koplik's spots, which are microscopic white lesions forming on the buccal mucosa, can surface during the prodrome and help identify measles. The prodromal symptoms are worse a few days before the rash appears. The distinctive maculopapular and erythematous rash initially develops on the face and behind the ears before centrifugally spreading to the trunk and limbs. Before going away in the same manner, the rash lasts for three to five days. Most fatalities from measles are brought on by pneumonia, and respiratory tract complications are common. The measles virus-induced immune suppression and local immunological dysfunction in the lungs both raise the risk of pneumonia.[10]

Table 1: Clinical manifestations and stages of Measles

Phase	Symptoms	Duration	Common Age Group
Prodromal	Fever, cough, coryza, conjunctivitis, Koplik spots	3 – 5 days	All ages
Rash Stage	Maculopapular rash (face→ trunk → limbs)	4 – 7 days	Children
Complications	Pneumonia, otitis media, encephalitis, diarrhea	Variable	Young children, immunocompromised

In those with impaired immune systems, the measles virus itself can produce giant cell pneumonitis or secondary bacterial or viral infections that can result in pneumonia. Otitis media and laryngotracheobronchitis (croup) are further respiratory problems. Rarely, measles can cause major CNS problems. One in every 1000 patients develops post-measles encephalomyelitis, primarily in elderly adults and children. Two weeks after the rash appears, encephalomyelitis sets in, characterized by fever, convulsions, and a host of other neurological problems. Immune responses to myelin basic protein, periventricular demyelination, and the lack of the measles virus in the brain all suggest that post-measles encephalomyelitis is an autoimmune condition caused by an infection with the measles virus.[10] Once common in some regions of the world, subacute sclerosing panencephalitis (SSPE) is a type of chronic measles encephalitis that has virtually vanished in nations where regular measles vaccination is required.[11]

Table 2: Common Measles-related complications and their management

Complication	Frequency (%)	Risk Factors	Treatment Approach
Pneumonia	5 – 10%	Malnutrition, Young age	Antibiotics, supportive care
Otitis Media	5 – 15%	Young children	Antibiotics
Encephalitis	0.1%	Immunosuppression	Supportive care, ICU
Diarrhea & Dehydration	8%	Vitamin A deficiency, malnutrition	Oral/IV rehydration therapy

4. Diagnosis

People who exhibit a fever and widespread rash should be evaluated for measles, especially if the virus is known to be circulating or if they have a history of visiting endemic regions. The clinical signs of measles, particularly Koplik's spots and rash, as well as possible locations for subsequent infections. The primary focus of an inspection of the body should be on conditions like otitis media and pneumonia. In healthcare settings, appropriate measures must be taken to stop transmission. Clinicians who are familiar with measles can diagnose it with ease. Koplik's spots are particularly useful since they are pathognomonic and show up before the rash. Making a clinical diagnosis is challenging in areas where measles is uncommon since most infections that show with fever and rash are caused by other viruses, especially the rubella virus in nations that have not implemented rubella immunization. An individual with fever, non-vesicular maculopapular rash, cough, coryza, or conjunctivitis is considered to have measles, according to the WHO clinical case definition.[10]

The most used technique for laboratory confirmation is serology. When measles virus-specific IgM is found in a serum or oral fluid sample, it is considered the most popular serological test for diagnosing acute infections. Research indicates that the sensitivity of the nasal swab polymerase chain reaction is almost 100%, which is superior to serologic testing. Alternatively, a four-fold or more increase in measles virus-specific IgG antibody concentrations between acute and convalescent samples can confirm acute infection. IgG antibodies against the measles virus in a single serum sample indicate prior infection or immunization, which cannot be differentiated serologically. Measles-virus-specific IgM antibodies often reach undetectable levels 4–8 weeks after rash development, but they may not be detectable for up to 4 days.[10]

Isolating the measles virus in cell culture from respiratory secretions, nasopharyngeal and conjunctival swabs, blood, or urine is another method of diagnosing measles. Reverse transcriptase detection of measles virus RNA Primers that target highly conserved sections of the measles virus genes can be used to amplify RNA taken from clinical specimens using PCR. In areas where measles has been eradicated, molecular epidemiology can be utilized to pinpoint importation origins.[10]

Newer commercial immunoassays have been found to have sensitivity as high as 93.7% to 98.8% and specificity of 96.8% to 97.9%, but the traditional reported sensitivity for the IgM enzyme-linked immunosorbent assay is 83% to 89% and specificity is 95% to 100% for specimens collected 3 to 28 days after the rash appears. Research indicates that the sensitivity of the nasal swab polymerase chain reaction is almost 100%, which is superior to serologic testing. Additionally, genotype identification is made possible by polymerase chain reaction, which is crucial for identifying connections between measles cases and outbreak control.[11]

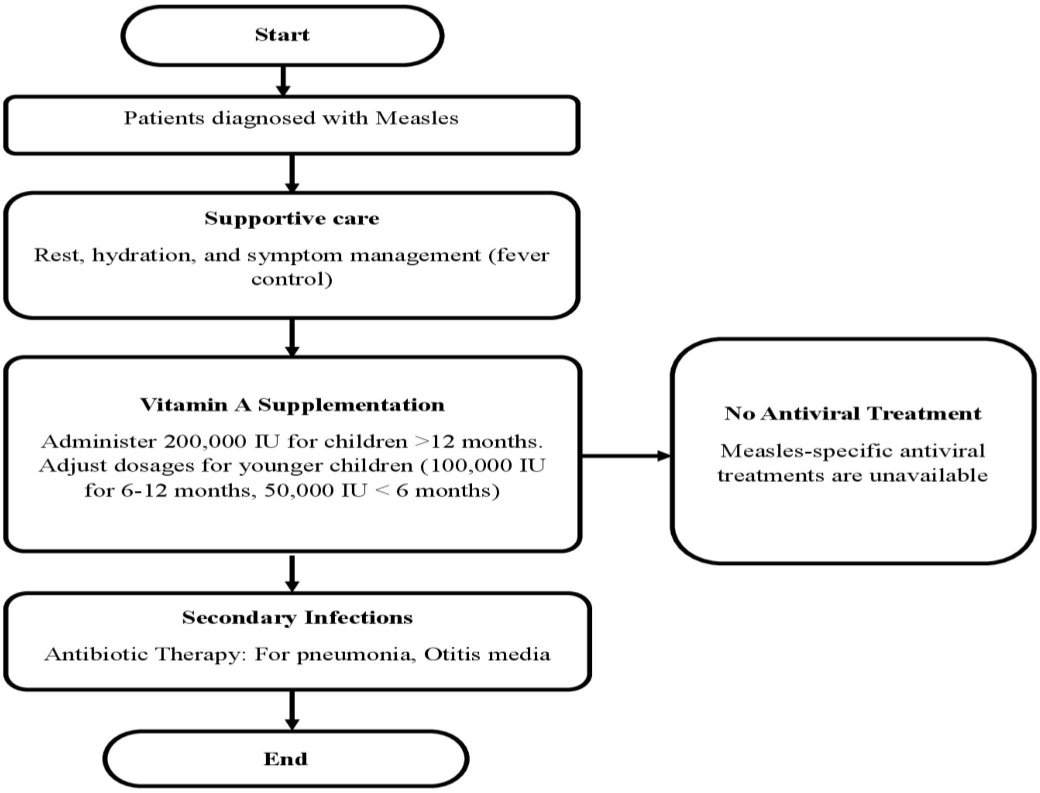
To make sure that patient isolation and standard and airborne precautions are in place, patients should be notified before being taken to a laboratory or emergency room. [10]

5. Treatment and Management

Supportive care is the main approach to treating measles and its consequences. [12] Measles can be effectively treated with vitamin A, which can also lower morbidity and death. The WHO advises providing measles vaccinations to all 12-month-old children or older with daily dosages of 200,000 IU of vitamin A for two days in a row. For younger children, lower dosages are advised: 100,000 IU daily for those 6–12 months old and 50,000 IU daily for those under 6 months. It is advised that children who exhibit clinical signs of vitamin A deficiency receive a third dosage two to four weeks later. All children with acute illness should get vitamin A to reduce the risk of consequences, such as blindness and death. [10,12] While antiviral drugs such as ribavirin and interferon α have been used to treat severe forms of measles, including infections involving the central nervous system caused by the measles virus, there is currently no particular antiviral therapy for measles patients. [10,11]

A significant contributing factor to morbidity and death after measles is subsequent secondary bacterial infections, and timely antibiotic therapy is essential to optimal case management. When a measles patient exhibits clinical signs of a bacterial infection, such as pneumonia or otitis media, antibiotics are recommended. The frequency of secondary bacterial infections following measles is likely to be reduced by vaccinations against *Streptococcus pneumoniae* and *Haemophilus influenzae type b*, which are frequent causes of bacterial pneumonia following measles. [10,12]

Figure 1: Treatment and management strategy for measles



6. Prevention and Vaccination

The live wild-type strains used to make MV vaccines were cultured in conditions that caused them to lose their virulence while still being able to elicit immunity. Vaccines that were both live and dead were first developed. It was noted that only temporary protection was provided by the inactivated vaccine, which led to immature antibodies and poor T-cell responses. This vaccine resulted in atypical measles, a more severe form of measles, and had been discontinued. Following additional development in the 1960s, these attenuated vaccines were less reactive and more appropriate for use in vaccination regimens that omitted gamma globulin.[13] These vaccines, most commonly paired with mumps and rubella vaccines (MMR), have been used extensively for many years, and they offer long-lasting defence, are safe, and are well accepted.[14]

The incubation time for a measles infection is eight to twelve days. People are contagious four days before or four days after the rash appears in a healthy host, but longer in immunocompromised individuals. During the infectious period, cases may arise up to 21 days following exposure. [12]

In affluent nations, children are inoculated against measles between the ages of 12 and 15 months, typically as part of the MMR vaccine. The vaccination is typically administered at this age to avoid vaccine contact with maternal anti-MV antibodies, which may prevent the vaccine viruses from being effective. A second dosage is often given to children aged four to five to boost immunity. During an epidemic with an elevated risk of exposure, MMR immunization can be initiated for infants as early as 6-9 months of age. Measles is now a relatively infrequent disease due to high vaccination rates. The most prevalent adverse effects of immunization are fever and injection site pain.[13] Less than 0.0001% of vaccinations cause life-threatening adverse events, such as lymphadenopathy, parotid gland edema, diarrhea, vomiting, febrile convulsions, urticaria, temporary thrombocytopenia, deafness, and meningitis/encephalitis.[14]

In developing nations where measles is particularly prevalent, WHO advises two doses of vaccine administered at six and nine months of age. The vaccine should be administered regardless of whether the child is HIV-positive or not. The immunisation is less beneficial in HIV-infected babies than in the overall population, however, early antiretroviral treatment can boost its efficacy.[14]

7. Recent Outbreaks and Ongoing Challenges

Recent measles outbreaks have presented substantial challenges to global elimination efforts. Large-scale epidemics in Georgia from 2013 to 2018 revealed ongoing immunity differences among age groups, necessitating targeted response measures.[15] Afghanistan confronts comparable issues, with refugee breakouts aggravated by political instability, a fragile healthcare system, and COVID-19.[16] Despite declaring measles extinct in 2000, the US has observed a recurrence of major outbreaks, especially in neighbourhoods with low vaccination rates. Vaccine hesitancy, lower immunization rates due to the COVID-19 pandemic, and case importation from endemic locations are all significant factors in this revival. Ensuring elevated vaccination coverage, and specifically among susceptible groups, is critical for outbreak management.[17]

Measles, which was proclaimed eliminated in the United States in 2000, has had a troubling recurrence in recent years. In 2025, major outbreaks were reported in Texas, New Mexico, and Pennsylvania, exposing continued public health issues. As of March 2025, Texas has 259 confirmed measles cases and one child mortality, while New Mexico had 35 cases and one death. The outbreak in these states began in a religious community with poor vaccination rates and has recently expanded to surrounding areas, including Oklahoma. Measles is highly transmissible, resulting in rapid case escalation, particularly among uninfected youngsters. Since January 2025, Pennsylvania health officials have identified 18 measles cases, largely in locations with vaccination rates below the 95% threshold required for herd immunity. Targeted immunization campaigns and public awareness measures have been used to help restrict the spread. [18-20]

The recurrence of measles in many states is closely linked to decreased vaccination levels. Vaccine hesitancy, driven by misinformation, complacency, and skepticism, has played a substantial role in this drop. In Texas, vaccine exemptions have increased, resulting in pockets of vulnerability where measles can spread quickly. Dr. Peter Hotez has underlined that unvaccinated populations act as a trigger for epidemics, similar to how "warm Caribbean waters" feed a storm. This decline in vaccination coverage not only facilitates measles transmission but also increases the risk for other vaccine-preventable diseases such as whooping cough and polio. The consequences of declining herd immunity extend beyond measles itself, posing a broader threat to public health and disease control efforts. [21-23]

In response to the epidemic, public health officials have implemented a number of interventions. In affected areas, vaccination schedules have been accelerated, with Texas health officials suggesting that newborns as young as six months receive their first MMR vaccination dosage, rather than the customary twelve months. Enhanced surveillance and containment efforts will involve rigorous contact tracing to quickly identify and isolate cases, as well as quarantine measures for exposed persons, particularly those who have not been vaccinated. Public awareness initiatives have also increased to combat disinformation and disseminate correct facts regarding vaccine safety and efficacy. Healthcare providers use trusted communication channels to engage communities, resolve issues, and encourage immunization. [24-26]

Despite these attempts, difficulties remain. The fast spread of measles underlines the necessity for continuing high vaccination rates alongside being attentive in public health. The current outbreaks serve as a sharp reminder of the dangers of diminishing herd immunity and the urgent need to maintain vigorous immunization programs. Without ongoing efforts to counteract disinformation and increase vaccine uptake, measles outbreaks will continue to constitute a major hazard to public health in the future years. [26-28]

8. Advancements in Research and Future Directions

Over the past century, there has been a significant decrease in measles-related deaths, initially as a result of advancements in health care, nutrition, and socioeconomic position, and then as a result of widespread measles vaccination.[29] Before measles vaccinations were widely used, there were over 2 million deaths annually; now, there are just over 100,000 deaths annually.[30] "The absence of endemic measles virus transmission in a defined geographical area for at least 12 months in the presence of a surveillance system that has been confirmed as performing well" is how the World Health Organisation (WHO) defines measles elimination. The measles virus possesses traits necessary for the total eradication of infection. Vaccination or previous infection can provide lifetime protection, and there is no animal reservoir for the human measles virus.[31] The WHO released the Big Catch Up, a global immunization recovery strategy for 2023 and beyond, on July 26, 2023. In light of the decreased vaccination uptake during the COVID-19 pandemic, this recovery strategy seeks to restore worldwide immunization efforts to their previous level of success. Three elements make up the WHO recovery plan: strengthen, restore, and catch up.[32] Key elements of creating focused interventions to reduce vaccine hesitancy include fostering community engagement, delivering clear and accurate information, and establishing trust.[33]

The development of paramyxovirus drugs has been hindered by several factors: A human challenge model has not yet been established for any paramyxovirus, which further exacerbates the problem. i) The viruses replicate quickly and cause primarily acute disease, so there are expected to be limited windows of opportunity for therapeutic intervention; ii) major clinical signs often reflect immunopathogenesis and the viral load is already in decline shortly after disease manifestation; iii) despite high disease prevalence, the size of treatable patient groups will likely be limited, constraining economic potential; iv) the majority of patients with paramyxovirus diseases is pediatric; and v) the size of treatable patient groups will likely be limited despite high disease prevalence.[34] Despite the aforementioned shortcomings, the first live measles vaccine was developed in the year 1962. To provide long-term protection against measles, the most popular vaccination combination to date is the MMR vaccine, which was combined in 1971.[35] The second dose of MMR vaccine was introduced in the year 1989 as Efforts to eradicate measles through single-dose vaccination campaigns have failed. One of the main reasons for the ongoing circulation has been primary vaccination failures brought on by maternal antibodies.[36] Immunocompromised individuals are susceptible to measles because they cannot receive a live virus vaccination. New subunit vaccination using stabilized measles fusion proteins such as mAb 77 for immunocompromised people and vaccinated people with declining immunity.[37]

Numerous epidemiologic studies have shown no connection between the MMR vaccine and autism, including one that found no association between the MMR vaccine and an increased risk of autism, even in children at increased risk whose older siblings had the disorder. Despite a wealth of evidence supporting the MMR vaccine's safety, certain parents are still hesitant to vaccinate their kids.[38]

Since 1987, the WHO and UNICEF have advised treating children with measles with vitamin A since vitamin A insufficiency is known to be a risk factor for severe measles. However, Vitamin A would not replace vaccines in preventing measles.[39]

9. Economic and Social Impacts

Measles outbreaks create major economic and social difficulties, especially in low-income populations. [40] Outbreaks have significant societal costs, including public health response charges, direct medical costs, and lost productivity. [41] A study in Ethiopia assessed the economic cost at $144.36 per case, with health sector expenses accounting for 80%.[42] In the United States, the economic cost of responding to outbreaks in 2011 varied from $2.7 million to $5.3 million. Limited healthcare access, low vaccine coverage, and a lack of information about the advantages of vaccinations are all factors that contribute to epidemics among vulnerable groups. [42,43]

The rise of measles has far-reaching economic and social effects, straining healthcare systems and upending communities. Measles outbreaks have a significant financial impact, which includes medical care, outbreak control efforts, and lost productivity. For example, the overall estimated cost of the 2012-2013 outbreak in Merseyside, UK, was £4.4 million, with 15% ascribed to NHS patient treatment expenses, 40% to public health costs, and 44% to society reductions in productivity. Similarly, the 2013-2014 measles outbreak in the Netherlands cost an estimated $2.9 million, with municipal health services bearing the majority of the expenditures, followed by inpatient bills. In the United States, 16 measles outbreaks in 2011 had a substantial economic impact, underscoring the strain on public health agencies. [41,44,45]

Beyond financial expenses, measles outbreaks have a profound impact on daily living, including schooling and job productivity. School closures and quarantine procedures have the potential to cause significant learning losses, particularly among children from low-income families. Parents are frequently obliged to miss work to care for sick children, resulting in economic instability and lower workforce participation. The social shame associated with measles epidemics may also discourage afflicted families from obtaining prompt medical attention, hampering disease control efforts. Furthermore, vaccine hesitancy, a major cause of recent outbreaks, has exacerbated community divisions, with disinformation driving distrust in Institutions of public health. The 2019 measles outbreaks in the United States, for example, cost an estimated $42 million in public health expenses, highlighting the financial burden on healthcare systems. [46-48]

Efforts to reduce these economic and social consequences necessitate ongoing investment in immunization programs and effective public health policies. Increasing vaccination rates can dramatically cut measles-related healthcare costs and prevent extensive societal disturbances. Public awareness programs that combat disinformation and highlight the collective benefits of immunization are critical for rebuilding confidence and providing community-wide protection against measles. Without urgent action, the economic and social ramifications of measles will continue to be a major problem for global public health systems. [49,50-52]

CONCLUSION

Despite the availability of vaccines, measles continues to be a major public health hazard. Over the last few decades, there has been a global decline in cases preventing outbreaks. However, sustained misconceptions regarding the vaccine, combined with growing vaccine hesitancy, risk undermining this progress. It is imperative to sustain public health interventions aimed at boosting vaccine coverage, dispelling misinformation, and informing communities about the significance of immunization. Through sustained eradication strategies aided with the help of WHO and UNICEF, the global burden of this preventable disease can be minimized and eventually eliminated. Ultimately, high vaccination rates are necessary not only for individual immunity but for the overall health of the society.

Abbreviations: MCV: Containing vaccine, MMR: Most commonly paired with mumps and rubella vaccines, SSPE: Subacute sclerosing panencephalitis

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