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Measles Outbreaks in the Post-Covid Era: Impact of Vaccination Gaps and the Need for Strengthened Immunization Programs

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Abstract
Measles virus (MeV) remains a significant public health challenge, particularly in the post-COVID era, where disruptions in immunization programs have exacerbated vaccination gaps. Despite the availability of a highly effective and safe vaccine, measles continues to cause severe morbidity and mortality, particularly among children under five. The recent resurgence of outbreaks worldwide highlights the urgent need for reinforced immunization strategies, continuous surveillance, and targeted vaccination efforts. This review explores the epidemiology, virology, and pathogenesis of MeV, focusing on the impact of vaccination gaps and the strategies required to achieve global measles eradication.

Keywords: *Measles virus, vaccine, epidemiology, Morocco, immunization gaps.*

1. Introduction

Measles is one of the most contagious viral diseases and represents a major global health challenge, particularly in regions where immunization coverage remains inadequate[1]. The causative agent, measles virus (MeV), is a rapidly spreading airborne pathogen that can cause serious complications, including pneumonia, encephalitis, and profound immunosuppression, and can ultimately lead to death [2]. Although an effective vaccine has been available for decades, persistent outbreaks worldwide, typically in regions of Africa, highlight significant gaps in immunization coverage. The COVID-19 pandemic has exacerbated this problem, interrupting routine immunization programs or mutations in circulating viral strains leaving millions of children vulnerable[3]. As a result, outbreaks continue to occur, making measles a leading cause of child mortality, with mortality rates varying across geographic and epidemiological settings[4].

2. Epidemiology

According to reports from the World Health Organization and the Centers for Disease Control and Prevention, the global incidence of measles has increased significantly in recent years. In 2023 alone, approximately 10.3 million cases were reported, an increase of 20% over the previous year[5]. In regions where vaccination coverage remains low, the mortality rate ranges from 0.05% to 6%, reflecting the severity of the disease in unprotected populations[6].

In Morocco, the situation is particularly worrying, with approximately 8,000 cases recorded in 2024. Of these, 2,753 cases were laboratory-confirmed and 19 deaths were reported. The outbreak, which began in October 2023, intensified in the following months with a case fatality rate of 0.2% across the country and an incidence rate of 21.1 per 100,000 inhabitants[7], prompting the Moroccan Ministry of Health to classify it as an unusual outbreak. Since September 2023, more than 25,000 cases and 120 deaths have been recorded, mainly affecting children under five and adults over 37[7].

3. Measles Virus (MeV) Biology and Pathogenesis

MeV belongs to the Paramyxoviridae family, within the Morbillivirus genus. It is an enveloped, negative-sense RNA virus ranging in size from 150 to 350 nanometers[6]. The viral genome consists of six genes encoding eight functional proteins, including nucleoprotein (N), phosphoprotein (P), matrix protein (M), fusion protein (F), hemagglutinin (H), and polymerase (L), all of which play essential roles in viral replication and immune evasion **(Fig1.)**[8].

Transmission occurs primarily through respiratory droplets, allowing the virus to initially infect the respiratory epithelium before disseminating to the lymphatic system. The primary cellular targets include CD150+/SLAMF1+ immune cells such as thymocytes, memory B cells, and T cells. In some cases, MeV may invade the central nervous system, leading to complications such as acute disseminated encephalomyelitis (ADEM), measles inclusion body encephalitis (MIBE), or subacute sclerosing panencephalitis (SSPE)[9].

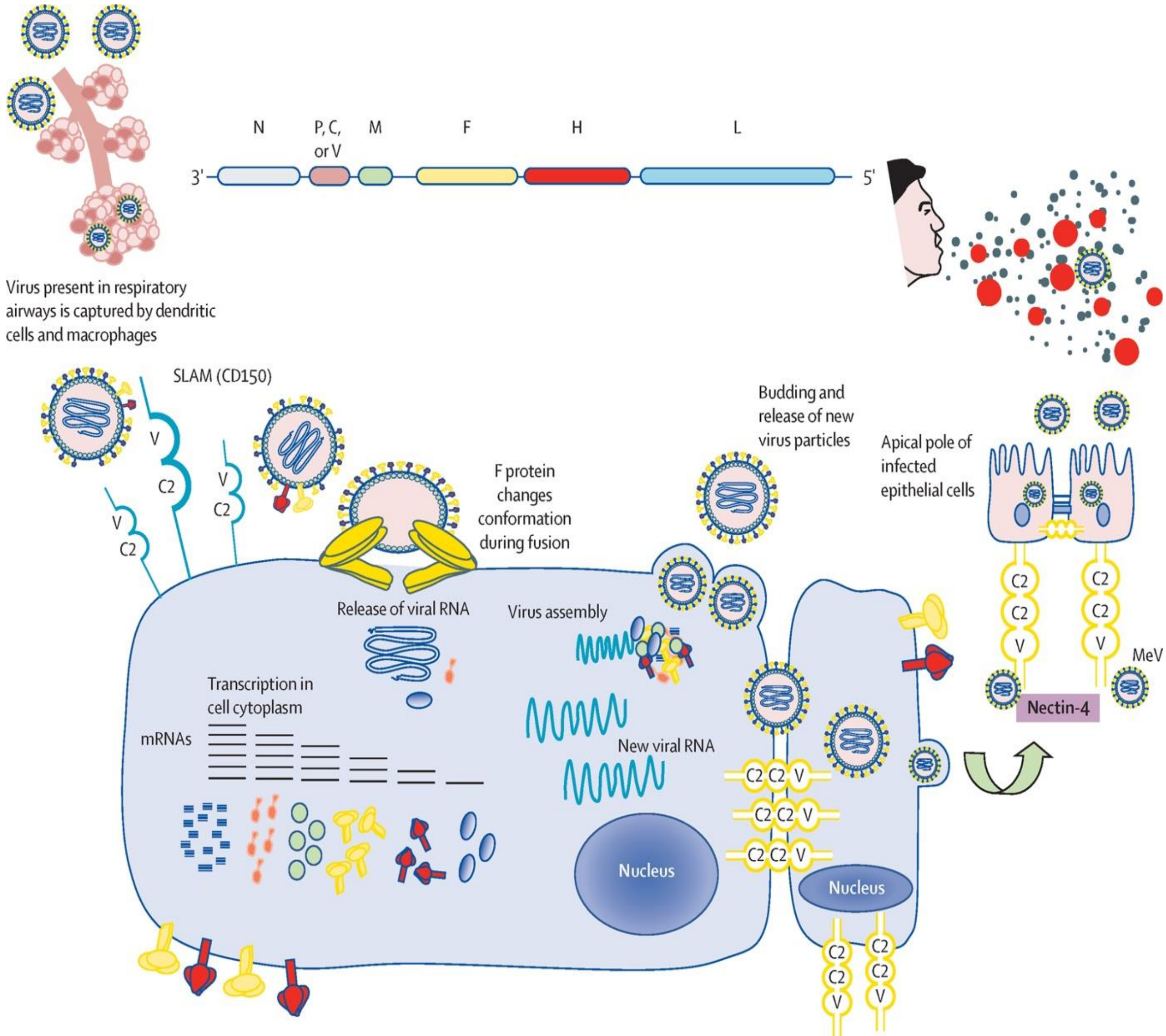


Figure 1. *Pathophysiology of Measles Virus Infection10***.**

4. Diagnosis

Clinical diagnosis is based on the presence of fever, maculopapular rash, cough, coryza or conjunctivitis. Kopli spots, although pathognomonic, are not always present and therefore must be confirmed biologically by laboratory tests, laboratory confirmation is essential for accurate case identification and outbreak control. Molecular methods such as reverse transcription polymerase chain reaction (RT-PCR) remain the gold standard for detection, targeting key genes including the nucleoprotein (N) gene for virus detection and genotyping, the hemagglutinin (H) gene for immune response assessment and the polymerase (L) gene for sequencing studies[11]. Serological tests play a complementary role in the diagnosis of measles. Detection of measles-specific IgM antibodies within 3–28 days of rash onset indicates acute infection **(Fig2.)**. Concurrently, a significant increase in IgG titres between acute and convalescent serum samples confirms either recent infection or vaccine-induced immunity[12].

Neutralization assays further provide insight into vaccine efficacy and potential reinfection risks[13 14].

For virus isolation, cell culture techniques remain relevant, though they are less frequently employed due to the time required. The virus is commonly propagated in Vero-SLAM cells or B95a cells, which are B-lymphoblastoid cells expressing the SLAM receptor, facilitating the efficient replication of MeV[15].

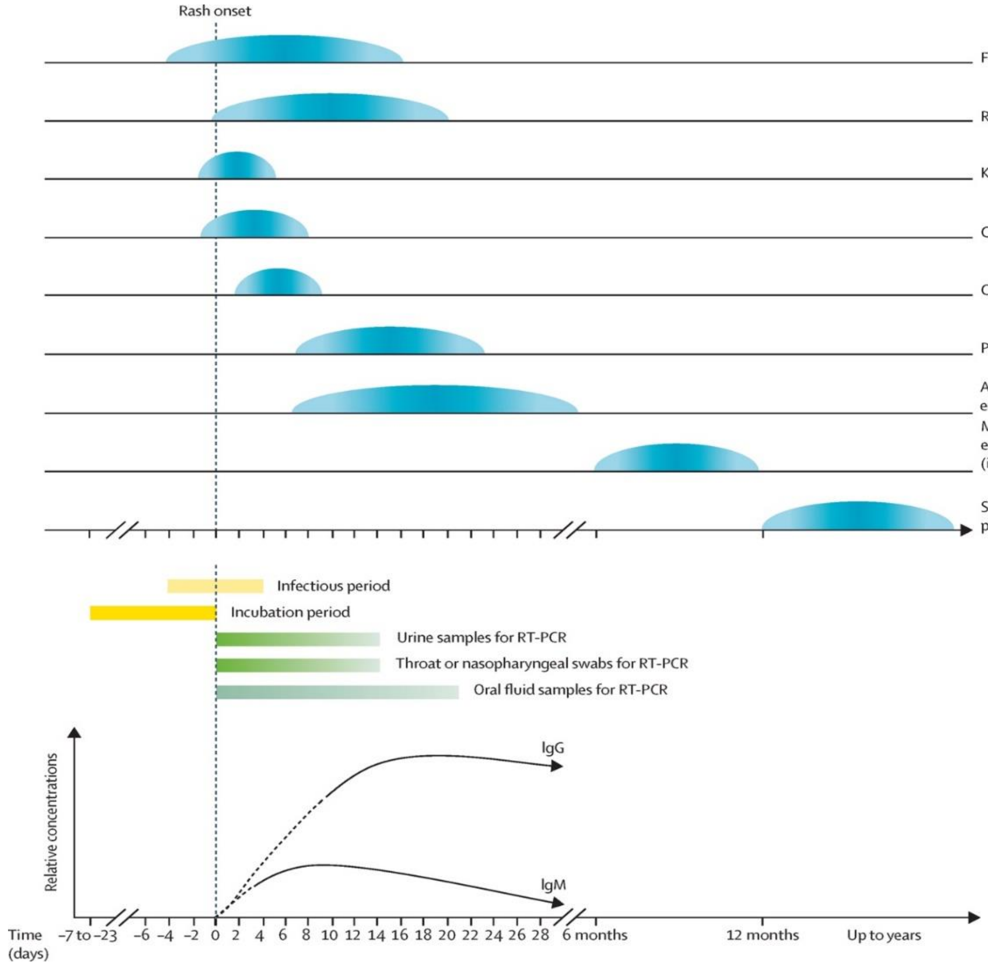
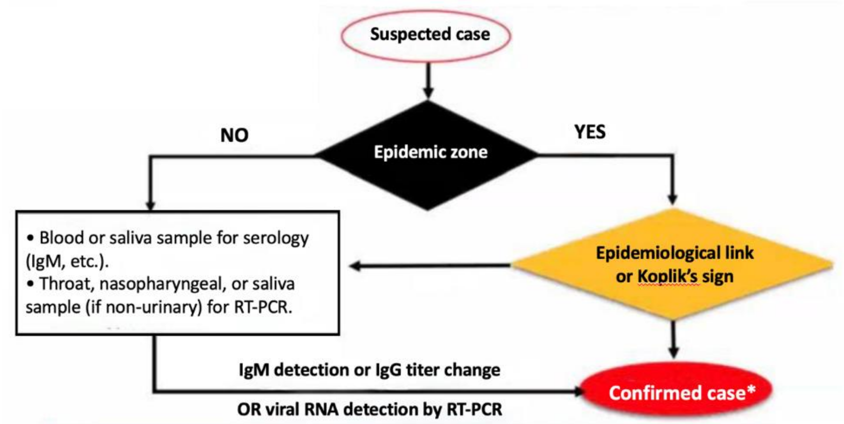


Figure 2. *Timeline of PCR and Serological Markers During Measles Infection and Contagion Period10*

5. Measles Vaccination And Immunization Strategies

The first measles vaccine was introduced in 1963, significantly reducing global incidence rates. Live attenuated vaccines have since replaced inactivated formulations due to their superior immunogenicity and long-lasting protection.



**Systematic confirmation regardless of the level of virus transmission for severe cases, immunocompromised individuals, pregnant women, and infants under 6 months of age.*

Figure 3. *Case confirmation flow chart18*

Morocco introduced measles vaccination in 1981, leading to a dramatic reduction in annual cases. Currently, the national immunization program follows a two-dose schedule, with the first dose administered at nine months of age and the second dose at eighteen months[16]. In response to the current outbreak, health authorities have intensified vaccination efforts, including catch-up campaigns targeting unvaccinated children and high-risk populations. The country has also adopted WHO/EMRO strategies to accelerate measles elimination, incorporating supplementary immunization activities to curb the spread of the disease[17].

Several vaccine formulations are available, including the monovalent measles vaccine (MV), the combined measles-mumps-rubella (MMR) vaccine, and the measles-rubella (MR) vaccine, which is used in specific catch-up campaigns. The success of these vaccination efforts is critical, particularly in light of the current outbreak. High herd immunity levels, with at least 95% coverage, are essential to prevent further transmission. Additionally, post-vaccination serosurveillance is necessary to monitor immunity levels and ensure long-term protection[12].

6. Conclusion

Measles remains a serious public health threat, particularly in the post-COVID era, where immunization gaps have contributed to a resurgence of outbreaks worldwide. The reinforcement of immunization programs, continuous surveillance, and targeted vaccination campaigns are fundamental to achieving global measles eradication. Morocco's efforts in controlling the current epidemic highlight the critical role of vaccination and public health interventions in mitigating the impact of measles.

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