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Mini-Narrative Review

The challenges and main recommendations to fight measles in India: A mini review

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ABSTRACT

The measles virus is an RNA virus belonging to the *Paramyxoviridae* family. It leads to an acute communicable illness that primarily involves the respiratory tract. Vaccination has significantly reduced the overall incidence and mortality worldwide; however, outbreaks still occur globally each year due to several factors. The SARS-CoV-2 pandemic has been a major hurdle since 2020. Despite the World Health Organization's goal to eradicate measles by 2023, there has been an increase in measles incidence in India, with 61,562 cases in 2022. Vaccination is a crucial preventive measure, and coverage needs to be increased through education, advocacy, and outreach to isolated communities.

1. Introduction

Measles is an acute illness, characterized by high-grade fever, coryza, cough, conjunctivitis, and Koplik spots. The incubation period ranges from 10 to 14 days, and the highly infectious phase lasts from 4 days before the development of maculopapular rash to 4 days following its appearance [1]. Commonly, measles can be complicated by otitis media and diarrheal infections, whereas less common but more serious and life-threatening complications include pneumonia, encephalitis, and subacute sclerosing panencephalitis. Pneumonia is the most common reason for deaths among children under 5 years and immunocompromised individuals affected by measles. Measles-related encephalitis results in seizures, hearing loss, and learning disabilities in children. Unvaccinated pregnant women are prone to delivering premature and low-birth-weight babies [2]. Measles has secondary attack rates above 90 %, making it a highly contagious disease. It spreads from person to person through large respiratory droplets and aerosolized particles after a person with the disease is present in an enclosed space for up to 2 h [3]. In addition to clinical symptoms, serological testing for specific IgG and IgM, viral isolation, and polymerase chain reaction are available for confirmation. There is no specific antiviral drug used to treat this illness; instead, only supportive care is provided [4]. It is preventable through vaccination, and achieving and maintaining over 95 % coverage will provide herd immunity and lead to the elimination of illness [5]. Over 6 million people are infected with measles each year, and 300 children die from it every day [6].

2. Main text

2.1. Literature search

A comprehensive literature search using PubMed, Google Scholar, Science Direct, and the Cochrane Library was carried out. Keywords used for search strategy included "measles," "measles virus," "India," and "outbreak." Articles reporting significant data on clinical picture, transmission, epidemiology, and hurdles faced while controlling measles in India were considered dating from 2000 to 2023. Exclusion criteria were based on articles irrelevant to our research objectives, not

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written in English language, poorly controlled trials, and animal model studies. References from the included articles were cross-checked to ensure the authenticity of the data.

2.2. Epidemiology

The measles virus is an enveloped, single-stranded RNA virus that belongs to the family *Paramyxoviridae, genus* Morbillivirus. Serologically, the measles virus is monotypic, although wild-type strains differ genetically. The World Health Organization (WHO) has standardized the nomenclature for genetic characterization of the measles virus and identified 24 genotypes, i.e., A, B1–B3, C1–C2, D1-D11, E, F, G1-G3, and H1–H2. Globally, only six genotypes (B3, D4, D8, D9, G3, and H1) have been identified in recent years. In 1980, the state government of Tamil Nadu was the first in India to introduce the measles vaccine. This was done with special permission from the central government as the vaccine was not yet licensed for use in the country [28].

In 1985, the measles vaccine was included in the national immunization program by the central government of India. The vaccines were imported initially, but by 1991, India had achieved self-sufficiency in this regard and was using locally produced vaccines, including measles. The vaccine was introduced to be administered to children at the age of nine to twelve months of age. A second dose of the measles containing vaccine (MCV-2) was introduced in 2010, for the age group of 16 months–24 months. In 2017, the measles containing vaccine was replaced by the measles and rubella containing vaccine (MRCV). After the introduction of the vaccine, cases decreased from 252,000 in 1987 to 36,900 in 2007 [29].

According to the National Family Health Survey of 2021 (NFHS 2019–2021) the overall percentage of children who have received the measles vaccine (MCV, MR, or MMR) has increased from 81.1 % to 87.9 %, which is an increase of 6.8 % from 2016 [30]. Whereas 95 % of the target population has received at least one vaccine for measles [31].

Since 2010, Supplementary Immunization Activity (SIA) has been done to improve the coverage of the second measles vaccine to achieve elimination, i.e., >95 % coverage [32].

In India, between 2005 and 2010, twenty-one states and two union territories reported cases of measles genotypes D4, D7, and D8; however, B3, D4, and D8 genotypes were confirmed during outbreak surveillance in 2017 [7,8].

Although measles is endemic all over the world, developing nations are more likely to experience high rates of death and morbidity. Before the introduction of immunization in the 1960s, measles killed nearly 8 million children annually and resulted in about 135 million cases annually throughout the world. However, from 2005 to 2010, India experienced 52 outbreaks, resulting in 2854 cases throughout 23 Indian states [9]. In 2012, more than one-third of the estimated measles deaths worldwide occurred in India. In 2015, a total of 25,514 cases of measles and 38 fatalities were reported, with West Bengal having 5425 cases and Kashmir having 2080 cases, being the most affected areas [10]. The incidence of cases per million throughout the years 2017–2021 has been illustrated in Fig. 1 [11].

Between October 2021 and September 2022, there were 172 documented measles outbreaks, resulting in 12,589 cases overall [12]. Centre of Disease Control (CDC) had globally ranked India as the measles capital with 61562 cases reported from September 2022 to February 2023 and recently placed 4th with 13220 cases reported between August 2023 and January 2024 [6].

2.3. Challenges

India has not had a single case of polio since 2011. Based on the experience of the Global Polio Eradication Initiative (GPEI) and the data gathered during the Supplementary Immunization Activities (SIAs), several challenges to the delivery of measles vaccines have been identified; these include: (1) considerable economic burden, which was offset in the case of polio by the GPEI, (2) increasing population and subsets of population who do not have access to immunization programs, such as migrants, refugees, and those living in makeshift housing; (3) lack of awareness or hesitancy towards immunization against a disease that is not common anymore, and (4) maintaining adequate vaccine supply has proven to be another challenge [32].

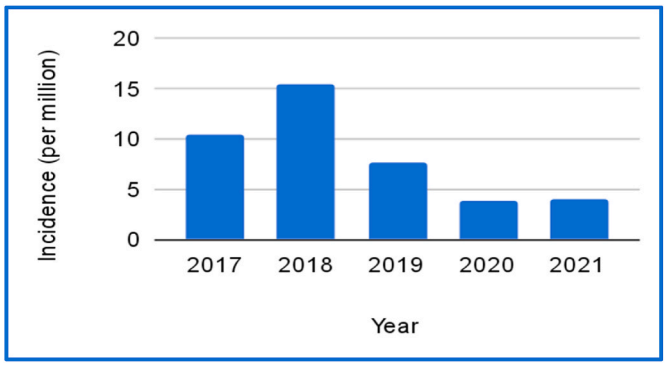

Fig. 1. Incidence of measles cases per million in India through the years 2017–2021.

Since October 2022, Mumbai, the largest and most important financial city in India, has been undergoing a large measles outbreak, reporting a significantly rising number of cases and mortalities [13]. In 2013, the countries of the South-East Asian Region of the World Health Organization (WHO), including India, pledged to eradicate measles from the region by 2020 [14]. Despite the efforts, India, among more than half of the member countries, failed to meet the desired target, owing to a multi-factorial contribution, the major factor being the COVID-19 pandemic. This resulted in insufficient vaccine coverage, which resulted in more than 3 million children in India being unimmunized [15]. In 2019, the WHO shifted the deadline to complete the elimination goal by 2023 [16]. but the burden of inadequate coverage in some states of the country was overwhelming enough that a massive outbreak led to India missing its target goal again. Public health officials and vaccination providers were implicated in overcoming the chaotic COVID-19 pandemic situation, which indirectly affected routine immunization and measles elimination programs across the country. Besides, India also faces an increased birth rate, with more than 25 million babies being born each year [17], which substantially enlarges the unvaccinated cohort. Social stigmas, public mistrust, and misapprehensions regarding vaccines also play a role in the under-immunization of less-educated communities in India. In addition, political mismanagement and a lack of funding significantly affect the cause [18]. According to a study, the estimated total campaign cost per MRCV dose endured by the Indian government ranged between US $0.14 and $0.32, without taking into account the delivery, vaccine, and syringes supplied by the WHO and UNICEF. The costs varied state-wise depending on the difficulty of accessing different areas, the number of children covered and vaccines used, the use of resources, and the healthcare personnel employed. Measles and rubella vaccines are supplied in multi-dose vials which, once uncapped, need to be discarded in 6 h, and many doses get wasted in underutilized areas. Public hesitancy towards vaccines in some states led to longer time periods to cover the target population, which indirectly extended the campaign expenses [19,20]. This hesitancy is not limited to just measles vaccination; COVID-19 immunization programs also faced similar opposition, with up to 12.3 % having objections towards vaccination [33].

In addition, the tracking systems used by health workers and surveillance teams miss out on many children of migrant workers who are left unvaccinated during the relocation of workers from Mumbai to their local homelands amidst the pandemic. Despite all these challenging obstacles, better strategic responses and policymaking can help control the outbreak in an efficient manner [21].

2.4. Recommendations

As the threat of COVID-19 faded, the health forces resumed their routine vaccination services, and the focus shifted back to covering the significant immunity gaps among children and pregnant women through catch-up vaccinations. The primary goal of Indian health authorities should be to preserve high-scale herd immunity through 95 % vaccination coverage, which can be achieved by improving the case-based surveillance of acute febrile illness and rash eruptions as seen in measles and rubella, for the rapid identification of high-risk settings and populations. Serological surveillance is a helpful technique for the laboratory confirmation of a suspected case, and sero-surveys should be applied in practice to aid supplementary immunization in children with missed doses and unknown vaccination status [22,23].

The WHO has launched a Measles and Rubella Strategic Framework (MRSF), according to which the surveillance and management of reported cases can be carried out in coordination as part of universal health coverage. Outbreaks should be foreseen, and healthcare teams should practice preparedness at all levels for early identification of cases and rapid action responses to reduce the morbidity and mortality ratio. The government should prioritize health needs at the national and state levels and provide immediate aid to frontline workers to maintain national health security at times of public health emergencies. The collection of monitoring data should be accurately handed over to the operational strategy developers for appropriate planning and policy-making. Modern-day innovations and advanced technology like GPS and digital surveillance software can be used for tracking, reporting, and recording cases on digital registers. Adequacy of vaccines and supporting supplies should be maintained; a need-based health budget should be defined and readily reserved for coping with the challenges of measles elimination and outbreak control [24].

The problematic vaccine delivery can be facilitated with the use of microarray patches specifically tested for measles and rubella vaccines. These are single-dose, dermal patches consisting of thousands of microprojections containing the vaccine, which bypasses needle and syringe use and the cold chain requirement. Although they have proven to be a potential success in clinical studies, they await extensive financial investment for high-scale manufacture and commercialization for prompt future application [25,26].

The campaigns should also focus on educating and taking the resistant communities into confidence with awareness strategies to deal with hesitancy and mistrust regarding vaccines. Health workers should collaborate with the local community, sect, and spiritual leaders to preach and educate about the health merits of the measles vaccine [13]. A specific study in Tamil Nadu highlighted the importance of leveraging social capital and public awareness in order to increase vaccine awareness. The vaccine acceptance rate was higher when it was offered at educational institutes and when students learned about it from their peers [34].

Vaccination records should be digitalized for proper maintenance using modern technology, as manual health records get misplaced and not updated. Digital records make it easier to trace the child's previous vaccination status. The latest computers and internet facilities should be provided to healthcare setups across Mumbai to store mother-and-child health records on digital portals [27].

Political consensus, mutual cooperation between public and health workers, accurate reporting and compilation of data, isolation of infected cases, and social media awareness campaigns should also be implemented in an effort to curb the rising atrocities of the ongoing outbreak, and external organizations should monitor the current progress in coherence with the national health councils for the accomplishment of the measles eradication program.

3. Ethics approval and consent to participate

This manuscript does not contain personal, human or animal data or details. Therefore, we have deemed it good not to appeal to the ethics committee for the approval of this work. For ethical approval, it was not applicable to our work.

4. Consent for publication

Not applicable.

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Shehroze Tabassum: Writing – review & editing, Writing – original draft, Visualization, Validation, Conceptualization. **Muhammad Hassan Hafeez:** Funding acquisition, Formal analysis, Conceptualization. **Aroma Naeem:** Supervision, Resources, Data curation, Conceptualization. **Arifa Bibi:** Funding acquisition, Formal analysis, Conceptualization. **Aymar Akilimali:** Writing – review & editing, Writing – original draft, Visualization, Validation, Supervision, Software, Resources, Project administration, Methodology, Investigation, Funding acquisition, Formal analysis, Data curation, Conceptualization. **Vishal Sharma:** Project administration, Investigation.

Declaration of competing interest

The authors declare that there no conflict of interest.

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List of abbreviations

(WHO)	World Health Organization
(UIP)	India Universal Immunization Program
(CDC)	Centre of Disease Control
(SIA)	Supplementary Immunization Activity
(MRCV)	measles- and rubella-containing vaccine

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