



Measles resurgence in Armenia: unmasking health system vulnerabilities and crafting comprehensive eradication strategies – a review

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Abstract

Measles is an acute febrile illness associated with rashes, fever and life-threatening complications. It is a vaccine-preventable disease with the Measles Mumps Rubella (MMR) vaccine but a recent global trend unveils a resurgence of measles in various parts of the world including Armenia. Measles was declared eliminated from Armenia in 2021 before reports of local outbreaks surfaced in 2023. The WHO identified discrepancies in the vaccination coverage during COVID-19. Measles also poses a great financial burden as a public health issue worldwide. Sociocultural factors impacting measles transmission are maternal education, healthcare access, migration, vaccine hesitancy, and socioeconomic status (Table 3). Efforts to control and eradicate measles from Armenia are run by a collaborative approach of national and international health bodies such as United Nations Children's Fund (UNICEF), WHO, Global Vaccine Alliance (GAVI), and the Ministry of Health. Thus, the resurgence of measles can be managed through widespread patient education, innovative approaches, strengthening the healthcare system and addressing vaccine hesitancy, sociocultural barriers, and humanitarian emergencies. This review investigates the complicated dynamics of measles inside Armenia's health system in depth. A thorough examination of measles incidence and immunization patterns highlights the shift from few cases and high vaccination rates to a comeback caused by imported viruses. The causes of its recurrence have been thoroughly investigated, including reduced immunization programs and vaccine hesitancy. The research delves further into the 'One Health' idea, assessing the possibility of interspecies transmission among nonhuman primates and examining the environmental factors that influence measles transmission. Among the challenges are weaknesses within Armenia's health system as well as the possibility of interruptions from the COVID-19 outbreak. In measles vaccination status, the combination of maternal education, postnatal care, and socioeconomic variables exposes the larger drivers at work. The study concludes with a comprehensive set of public health policy recommendations covering vaccination promotion, surveillance, healthcare provider education, public awareness, international collaboration, data analysis, law enforcement, emergency preparedness, research, and coordination. The research sheds light on the tangled web of measles dynamics, health system resilience, and contextual subtleties via this multifaceted approach, inviting readers to investigate the multiple strategies required for eliminating measles in Armenia.

Keywords: Armenia, health system, measles, public health, vaccination

Introduction

Measles, once a major threat to child health in the prevaccination era, is a highly contagious and acute febrile illness associated with rashes and various complications. The mode of transmission is via respiratory droplets, and the clinical features include

prodromal fever, cough, conjunctivitis, and maculopapular rash^[1]. Measles can have serious complications in the form of pneumonia, otitis media, and life-threatening neurological complications such as encephalitis, subacute sclerosing panencephalitis (SSPE), and measles inclusion body encephalitis (MIBE)^[2]. However, with the introduction of the Measles, Mumps, and

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Rubella (MMR) vaccines, it is now labeled as one of the vaccine-preventable illnesses. Although it is considered a childhood illness, the disease can affect individuals of all ages. Recently, measles has exhibited a resurgence trend globally^[3]. Considering the example of the US, measles was eliminated from the country in the 2000s and remained so through 2011. A secondary incidence of the disease was seen afterward when cases kept coming in^[4]. All the reported cases were either children whose parents refused vaccination or travelers^[5]. Thus, many countries since then have shown a similar epidemiological pattern of resurgence, making it one of the major global public health concerns recently.

Armenia is one of the members of the Commonwealth of Independent States (CIS) and has a developing healthcare system that is facing numerous public health challenges^[5]. The instability of Armenia's healthcare system has invoked high dissatisfaction among its population, where half of the respondents remain unhappy with the overall health services^[6]. Armenia's healthcare response to measles disease was studied by Kantner *et al.*^[7], and the authors report that although vaccination coverage is part of the healthcare system following the recommendations of the WHO, the overall vaccination coverage is still far below the recommended target of 95%. Moreover, the authors highlighted discrepancies in the local surveys in comparison to the WHO. Furthermore, there is a possible delay in the vaccination, making it less effective^[4,5]. Thus, Armenia's weak healthcare system and its ineffective measures against measles vaccination, control, and eradication contribute to putting the region at high risk for future measles outbreaks. Therefore, this review aims to underscore the critical areas of healthcare that demand attention and broaden the understanding of the measles trend and associated factors underlying resurgence and highlights the eradication strategies applied.

Materials

This narrative review on measles in Armenia is done with the help of extensive literature search through various databases like PubMed and Google Scholar as well as national news articles with the following search terms and their combinations: measles in Armenia, resurgence of measles, healthcare system of Armenia, measles trend in Armenia, health strategies applied for eradication of Measles.

The data were collected through the various authentic websites of WHO, UNICEF, and Armenian ministry of Health. Various articles were carefully selected with the aim of providing legit source and information.

Measles epidemiology and trends in Armenia

Since 2023 began, measles cases have been reported in 17 countries in the WHO's European Area^[6]. By the end of February, more instances had been reported than had been written for the entire year of 2022—over 900. The 11th meeting of the European Regional Verification Commission for Measles and Rubella Elimination confirmed measles elimination in Armenia in 2021^[4,5]. There were only 1437 cases in 2019 in Armenia (Fig. 1) (Table 1). As per WHO EpiData, among a population of 2 780 469, there were zero cases of measles from March 2022 until February 2023. Despite maintaining the elimination, there was a local outbreak of measles in early March 2023^[6]. According to the Public Media of Armenia, quoting the

HIGHLIGHTS

- Measles resurgence in Armenia despite previous elimination efforts.
- Vaccination coverage gaps and challenges in measles control strategies.
- Impact of measles outbreaks on public health systems and finances.
- Importance of a comprehensive approach integrating vaccination, surveillance, and public awareness.
- The need for collaborative efforts and innovative strategies for regional measles elimination.

Ministry of Health, 525 cases of measles were confirmed in laboratories as of 18 December 2023. The majority of these cases affected young people. National Center for Disease Control (NCDC) Armenia has submitted information on 374 cases among children and 151 among adults. Among the cases, 2 people had been admitted and 350 had been discharged^[8].

Identifying the gaps in vaccination coverage

In Armenia, measles is vaccinated alongside mumps and rubella as part of the MMR vaccine. Whenever a baby turns 13 months old, they receive their first dose. The second dose is administered between the ages of four and six. They also receive a booster shot between the ages of 15 and 16^[9]. Measles vaccination coverage in Armenia was estimated at 94% with both doses in 2020 and 2021, which falls within the 92–95% required to prevent wider community transmission^[9,10]. But around 61 million doses of the measles-containing vaccine were delayed or skipped, according to the Centers for Disease Control and Prevention (CDC), as a result of COVID-19-related delays in additional immunization programs globally. Kantner *et al.*^[7] mention that there may even be a discrepancy between household surveys and WHO/UNICEF reports because the mean age of the children in the vaccine group was 23.15 months when it was supposed to be 12 months. The WHO also reports that a sizable portion of measles cases in Armenia have an undetermined or ambiguous vaccination history. Perhaps maternal education is another element causing the measles outbreak. Given the advantages of maternal education for children's health, this might come as a surprise. Children of educated mothers did not have a noticeably higher vaccination rate than those of uneducated mothers. It may indicate a trend in Armenia that has been observed in other, mostly high-income

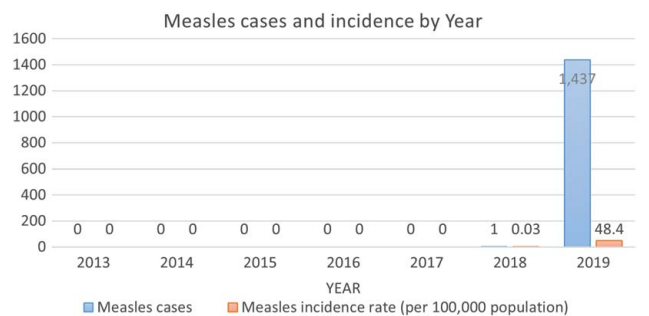


Figure 1. Measles cases and incidence rate (per 100 000 population).

Table 1
Measles epidemiology and vaccination coverage trends in Armenia (2013–2019).

Year	Measles cases	Measles incidence rate (Per 100 000 population)	Measles vaccination coverage (%)
2013	0	0	97
2014	0	0	97
2015	0	0	97
2016	0	0	97
2017	0	0	97
2018	1	0.03	96
2019	1437	48.4	N/A

situations, where clusters of vaccine hesitancy emerge among highly educated people^[9]. Vaccination in general and measles are also some of the most affected public health issues in cases of humanitarian emergencies, wars or refugee movements due to disruption of health services and mass internal displacements aiding the spread of vaccine preventable diseases^[11].

Impact of measles outbreaks on public health

Outbreaks of diseases put an immense burden on healthcare facilities and often lead to hospital resource exhaustion. It is even difficult for the developed healthcare systems to sustain themselves in such critical situations, whereas the healthcare systems of the developing and underdeveloped countries collapse altogether. Through a literature search, it is known that the United States spent \$394 448 to control the 2013 measles outbreak in New York City^[10]. The breakdown of these numbers involves the use of this sum on paying staff members, MMR vaccination, advertising, and laboratory testing, mainly. Furthermore, in total, 10 054 h were officially spent on dealing with this outbreak in the form of controlling and responding. Hence, these resource-intensive control measures redirected the finances away from other attention-seeking public health matters^[12]. In another study, the authors presented the impacts of the 2013 measles outbreaks in the United Kingdom in terms of direct and indirect costs^[9]. Direct costs include treatment of cases (£678 300) and public health costs (£1 764 400) for control and containment. Indirect costs include the financial implications of work absence and school closures (1 952 700). Thus, the total financial burden of the outbreak totals £4 395 400^[9,12]. On the other hand, a hospital outbreak of measles occurred in Germany during the year 2017, costing 700 000 euros for the control and containment of only 10 cases^[13]. Furthermore, an Australian study reports an amount exceeding A\$48 000 spent by the public health department to contain the measles outbreak in western Sydney in 2011^[14]. Similarly, another study discussed the cost of the measles outbreak on public health departments in the USA, along with the estimated personal hours spent on tackling the outbreak. The study reports that for the 16 measles outbreaks combined, the public healthcare department suffered a burden of around \$5.3 million, while the staff spent more than 83 000 h on this in 2011^[15].

In addition to the financial implications associated with the measles outbreaks globally, such disease outbreaks also substantially impact vulnerable populations in terms of socio-economic crises. The major causes of measles outbreaks are geographically varied, and thus authors attribute various factors

like ‘floating populations’ and population densities to being contributing causes of the recurrent and uncontrollable spread of the disease among vulnerable groups of individuals^[16]. Moreover, poor vaccination coverage, travel history, contact with the measles-case patient, and the educational status of the parents also play a part in the spread of outbreaks^[16–18]. Another important consideration for the measles outbreak is particularly seen in war-struck countries like Ethiopia, where ongoing war situations hamper effective healthcare delivery to vulnerable populations, thus propagating outbreaks^[18]. Thus, numerous causes contribute to the occurrence and spread of measles outbreaks, and the study of geographical etiologies is the key to understanding the disease epidemiology and therefore the steps for disease control.

Innovative approaches to outbreak control

Outbreaks of infectious diseases such as Hepatitis C and COVID-19 are a public health problem^[19,20], so it is important to apply efficient strategies for their prevention, and what better way than using technology to achieve it? This is how the area of research on the prognosis of infectious diseases will be of great value in being able to anticipate their appearance or re-emergence.

Digital health surveillance technologies such as cell phone geolocation, closed-circuit cameras, and applications turn out to be a new opportunity to improve prevention, detection, monitoring, notification, and analysis^[16]. A worldwide precedent is the case of the COVID-19 pandemic, where digital surveillance technologies and massive public data collection were used to detect and mitigate contagion and ensure compliance with public health measures. However, as surveillance technology develops, a way to effectively monitor it is needed to prevent data from being misused. The Centers for Disease Control and Prevention (CDC) offers digital resources and even created a global response plan called the Global Measles Outbreak Response Strategic Plan 2021–2023 that addresses strategies for action at the global, national, and regional levels^[16,17]. Community-based interventions are effective for health promotion and disease prevention, but their full potential has not been realized so far (Table 2). An important pillar is the dissemination of messages to the population, which includes the news provided. The messages must be clear and concise on the part of the authorities or diffusion agents. The population must be adequately informed, for which the CDC provides information on how to have adequate communication during an outbreak^[18,21].

Cultural and social determinants of measles transmission

Acceptance of vaccinations, healthcare use, and illness prevention strategies can all be influenced by cultural norms, behaviors, and beliefs (Table 3). Traditional ways of life in some societies could entail communal living or close social interactions, which raises the risk of quick illness spread^[22].

Vaccine reluctance can undermine immunization efforts because of false perceptions about vaccines, which are frequently based on cultural values, the example of this is poor vaccine acceptance in Pakistan^[23]. Having a thorough understanding of cultural settings enables public health campaigns to successfully

Table 2
Comprehensive assessment of measles dynamics and influences in Armenia.

One health aspect	Measles situation in Armenia
Human health	Armenia had zero measles cases and high vaccination coverage from 2013 to 2017 and was verified as having eliminated both measles and rubella by the WHO. However, in 2018 and 2019, there was a resurgence of measles cases in Armenia, mainly due to imported cases from neighboring countries. The vaccination coverage data for the recent years are not available yet, but it is possible that there was a decline in the immunization program or an increase in vaccine hesitancy. The data for the years 2020 to 2022 are also not available yet, but it is likely that the COVID-19 pandemic has disrupted the measles surveillance and prevention effort ³ . In 2023, there were 46 confirmed measles cases in Armenia by March, with most of them occurring among children under the age of eight
Animal health	Measles virus is primarily a human pathogen, but it can also infect some nonhuman primates, such as monkeys, apes, and lemurs. These animals can serve as reservoirs or sources of infection for humans, especially in areas where they have close contact with people. There is no evidence of measles virus infection in domestic animals or wildlife in Armenia, but there is a potential risk of spillover from humans to animals or vice versa
Environmental health	Measles virus can survive in the air or on surfaces for up to two hours and can be transmitted through respiratory droplets or direct contact with infected persons or objects. Environmental factors such as temperature, humidity, sunlight, and air quality can affect the stability and transmission of the virus. In Armenia, the climate is continental, with hot summers and cold winters. The air pollution level is moderate to high, especially in urban areas. These factors may influence the spread and severity of measles outbreaks in Armenia

modify their messaging, addressing issues while maintaining cultural sensitivity.

Moreover, religious practices and gatherings can foster disease transmission if not managed according to health guidelines. Exploring these cultural dynamics helps develop strategies that align with local values, promoting better adherence to preventive measures. By acknowledging and analyzing cultural practices and beliefs, public health interventions can mitigate the impact of measles by fostering community trust, promoting accurate health information, and enhancing overall disease control efforts^[24].

Social networks and mobility play crucial roles in the dissemination of the measles virus. Measles is highly contagious, and its spread thrives on close human interactions. Social networks, both physical and virtual, facilitate rapid transmission as people come into contact with infected individuals. Mobility further accelerates this process as infected individuals move within and between communities^[18,21,25].

Physical gatherings, such as schools, public transportation, and crowded events, enable measles to quickly jump from person to person. In a digital era, social media platforms amplify the reach of information, including misinformation about vaccines, impacting individuals' decisions on vaccination. Increased global mobility allows the virus to cross borders, leading to outbreaks in previously controlled regions^[22].

Efforts to curb measles transmission must address these factors. Effective vaccination campaigns, public health awareness, and accurate information dissemination through both physical and virtual social networks are essential. Furthermore, monitoring and managing mobility, especially during outbreaks, can help prevent the rapid expansion of measles transmission across various communities^[16–18].

Collaborative efforts for regional measles elimination

The Ministry of Health of Armenia has frequently advised unvaccinated Armenians to get immunized against measles in recent days. UNICEF has consistently supported the implementation of children's immunizations in Armenia and continues to be committed to this cause. 'Since 1994, UNICEF has assisted the Government of Armenia in the procurement of vaccines, syringes, safety boxes, and cold-chain equipment for six WHO-targeted vaccine-preventable diseases (tuberculosis, diphtheria, pertussis, tetanus, polio, and measles)^[26]. They also encouraged the introduction of novel antigens, such as vaccinations for measles, mumps, and rubella (MMR). This work was supplemented by health worker training, health education and communication operations, and the upgrade of the national surveillance system. They were able to alleviate supply bottlenecks and maintain high immunization coverage because of their

Table 3
Socio-cultural factors influencing measles dynamics in Armenia.

Cultural and social determinant	Measles situation in Armenia
Education	Maternal education was found to be an important factor associated with measles vaccination status in children under the age of three years in Armenia. Children whose mothers had secondary education were more likely to be vaccinated than those whose mothers had primary or no education
Health care access	Attendance at postnatal check-up within two months after birth was also found to be a significant predictor of measles vaccination status in children under the age of three years in Armenia. Children who attended postnatal care visits were more likely to be vaccinated than those who did not
Vaccine hesitancy	Concerns about vaccine safety and efficacy are common in Armenia, especially among parents of young children. Some parents may refuse or delay vaccinating their children due to mistrust of health authorities, fear of adverse effects, or lack of awareness of the benefits of immunization
Migration	Imported cases of measles from neighboring countries were the main source of infection for the resurgence of measles cases in Armenia in 2018 and 2019. Some of these cases were among travelers or migrants who had not been vaccinated or had incomplete vaccination histories
Socioeconomic status	Socioeconomic status may also influence the measles vaccination coverage and outbreak risk in Armenia. Poverty, unemployment, and inequality may limit the access to health care services and information, as well as increase the vulnerability to infectious diseases

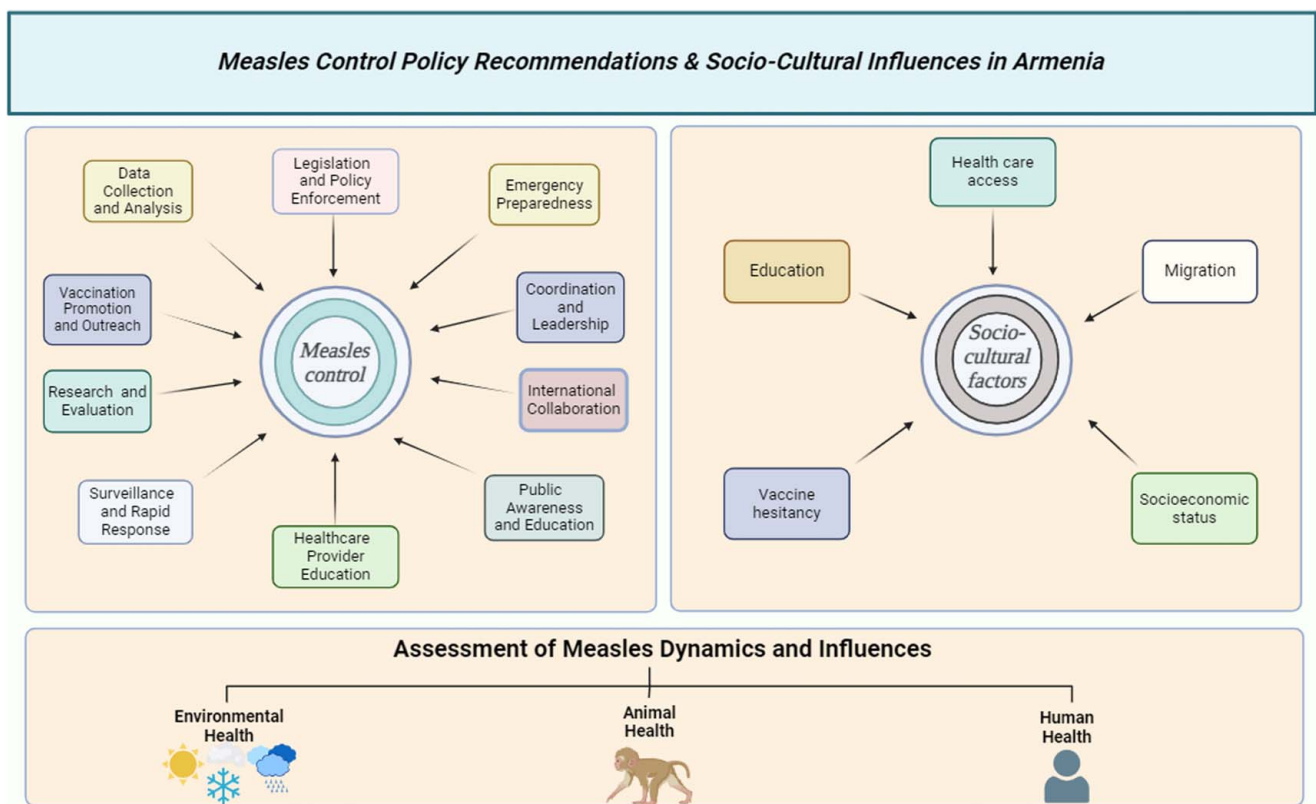


Figure 2. Socio-cultural factors, one-health approach, and public health policy recommendations for measles control.

collaboration (Fig. 2). With additional support from UNICEF in Armenia, the Global Alliance for Vaccines and Immunization (GAVI) assists the Armenian Government in maintaining its achievements in disease prevention while also moving toward self-sufficiency^[27,28].

Steps taken by the armenian government to control measles

Measles has been a public health challenge for Armenia for long. Some of the noticeable efforts by the health authorities in the direction of measles are catch-up campaigns to increase vaccination rates. The first campaign was run in 1986, followed by several rounds in 1997 and 2007^[29].

Armenian government also put in place ‘The National Strategic Plan on Measles and Rubella Elimination’. Moreover, measles is part of a broad surveillance system which is based on a four level reporting system to promptly identify the cases^[29].

In comparison, vaccination rates for measles have also increased following mass immunization campaigns handled by the ministry of health, UNICEF, WHO, and Rostropovich Vishnevskaya Foundation^[30].

Public health policy recommendations

The WHO considers measles to be a vaccine-preventable disease, and Armenia follows WHO guidelines for childhood vaccination (Table 4). Armenia has requested that people follow routine vaccination for children against measles, and people who are unsure about their vaccine status should visit an Out Patient

Department Clinic (OPDC) or mobile vaccine setup for their vaccination.

Measles immunizations are available at all outpatient clinics in Armenia. Mobile units are set up to ensure that vaccine access is

Table 4
Public health policy recommendations for measles control in Armenia.

Policy area	Recommendations
Vaccination promotion and outreach	Strengthen routine measles vaccination program Conduct vaccination campaigns Collaboration with healthcare providers and schools
Surveillance and rapid response	Establish robust surveillance system Develop laboratory network Implement rapid response mechanisms
Healthcare provider education	Provide ongoing education and training Address vaccine hesitancy
Public awareness and education	Develop targeted public health campaigns Address vaccine misinformation
International collaboration	Collaborate with international organizations and neighboring countries
Data collection and analysis	Collect and analyze data on measles cases and vaccination coverage
Legislation and policy enforcement	Implement mandatory vaccination policies Enforce accurate reporting
Emergency preparedness	Develop measles outbreak response plan Stockpile vaccines and supplies
Research and evaluation	Invest in research to understand vaccine hesitancy Regularly evaluate impact
Coordination and leadership	Designate lead agency Establish advisory committee

not a problem. Adults who are unsure whether they have been vaccinated against measles and have come into contact with infected people should receive the vaccination within 72 h. The government has requested that all healthcare workers be careful, as they can be the source of infection for the spread of measles. Proper screening, isolation, and supportive care are advised for the treatment of measles. As it is a vaccine-preventable disease, the Ministry of Health has requested that people get their children vaccinated as per schedule, and adults who have never been infected with measles or have never been vaccinated have the vaccine as well.

Patient education

Measles is a highly contagious disease with widespread impacts on children as well as adults. The underlying cause of this condition is the measles virus (MeV), which spreads through respiratory droplets. After entering the body, MeV spreads through organs silently until about 2 weeks when fever and rash appear. This disease is; however, preventable through childhood vaccinations via a three-dose schedule given subcutaneously or intramuscularly^[31].

Treatment of measles is only supportive as there is no specific antiviral therapy against the virus. The role of vitamin A and Zinc are commonly discussed in association with measles therapy^[32,33].

Limitations

The literature search for this review was not based on the systematic review of the studies, thus there is a likelihood of missing important studies is there.

Conclusion

In conclusion, measles in Armenia exhibits a resurgence in public health trends demanding a comprehensive approach that targets vulnerabilities within the healthcare system to eradicate the disease. Measles is an infectious and financial burden for any country with weak healthcare systems and humanitarian emergencies. Thus sustained efforts by local government are imperative to educate people along with increasing vaccination coverage and minimizing cultural beliefs acting as vaccination barrier. Sustained vigilance is a cornerstone in the battle against sporadic outbreaks, while judicious resource allocation becomes paramount for the effective implementation of outbreak control measures. Eradicating measles in Armenia requires bolstering healthcare systems, implementing comprehensive vaccination policies, fostering cultural sensitivity, forging collaborations with international entities, and embracing innovative methodologies. These multifaceted measures are not only imperative for achieving the desired outcome but also pivotal in safeguarding the well-being of the populace.

Ethical approval

Ethics review was not required for this review.

Consent

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All authors contributed in the manuscript writing, and all the reviews formed in the process. SA and MSG came up with the idea.

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References

- [1] unicef. Every dose counts. The measles outbreak and missed vaccinations | UNICEF [Internet]. Accessed 20 Aug 2023. <https://www.unicef.org/armenia/en/stories/every-dose-counts-measles-outbreak-and-missed-vaccinations>
- [2] Asbarez. Measles Outbreak Hits Armenia – Asbarez.com [Internet]. [cited 2023 Aug 20] <https://asbarez.com/measles-outbreak-hits-armenia/>
- [3] unicef. It hurts, but it works! | UNICEF [Internet]. Accessed 20 Aug 2023. Available from: <https://www.unicef.org/armenia/en/node/516>
- [4] Gastañaduy PA, Funk S, Lopman BA, *et al.* Factors associated with measles transmission in the United States during the postelimination era. *JAMA Pediatr* 2020;174:56–62.
- [5] Bailey A, Sapra A. MMR vaccine. *StatPearls*. StatPearls Publishing; 2022.
- [6] Du E, Chen E, Liu J, *et al.* How do social media and individual behaviors affect epidemic transmission and control? *Sci Total Environ* 2021;761: 144114.
- [7] Kantner AC, van Wees SH, Olsson EMG, *et al.* Factors associated with measles vaccination status in children under the age of three years in a

- post-soviet context: a cross-sectional study using the DHS VII in Armenia. *BMC Public Health* 2021;21:552.
- [8] abc media. Laboratory-confirmed cases of measles in Armenia reach 525- [Internet]. Accessed 18 Dec 2023. <https://abcmedia.am/en/news/24419/>
- [9] Ghebrehewet S, Thorrington D, Farmer S, *et al.* The economic cost of measles: healthcare, public health and societal costs of the 2012–13 outbreak in Merseyside, UK. *Vaccine* 2016;34:1823–31.
- [10] Girmay A, Dadi AF. Being unvaccinated and having a contact history increased the risk of measles infection during an outbreak: a finding from measles outbreak investigation in rural district of Ethiopia. *BMC Infect Dis* 2019;19:345.
- [11] Grundy J, Biggs BA. The impact of conflict on immunisation coverage in 16 countries. *Int J Health Policy Manag* 2019;8:211–21.
- [12] Harutyunyan T, Hayrumyan V. Public opinion about the health care system in Armenia: findings from a cross-sectional telephone survey. *BMC Health Serv Res* 2020;20:1005.
- [13] Hiller U, Mankertz A, Köneke N, *et al.* Hospital outbreak of measles – Evaluation and costs of 10 occupational cases among healthcare worker in Germany, February to March 2017. *Vaccine* 2019;37:1905–9.
- [14] Flego KL, Belshaw DA, Sheppard V, *et al.* Impacts of a measles outbreak in western Sydney on public health resources. *Commun Dis Intell Q Rep* 2013;37:E240–5.
- [15] Nazir A, Oduoye MO, Tunde AM, *et al.* Measles outbreak in Ethiopia amid COVID-19: an effect of war-induced hampering of vaccination and pandemic. *Ann Med Surg* 2023;85:1336–9.
- [16] Ortega-Sanchez IR, Vijayaraghavan M, Barskey AE, *et al.* The economic burden of sixteen measles outbreaks on United States public health departments in 2011. *Vaccine* 2014;32:1311–7.
- [17] Patterson MC. Neurological complications of measles (Rubeola). *Curr Neurol Neurosci Rep* 2020;20:2.
- [18] Pike J, Leidner AJ, Gastañaduy PA. A review of measles outbreak cost estimates from the United States in the postelimination era (2004–2017): estimates by perspective and cost type. *Clin Infect Dis* 2020;71:1568–76.
- [19] Ali RA, Awadalla EA, Amin YA, *et al.* The deleterious effects of sofosbuvir and Ribavirin (antiviral drugs against hepatitis C virus) on different body systems in male albino rats regarding reproductive, hematological, biochemical, hepatic, and renal profiles and histopathological changes. *Sci Rep* 2024;14:5682.
- [20] Amin YA. Effects of SARS-CoV-2 infection on pregnancy outcome: an overview. *Asian Pacific J Reproduct* 2023;12:155–61.
- [21] Qin S, Ding Y, Yan R, *et al.* Measles in Zhejiang, China, 2004-2017: population density and proportion of floating populations effects on measles epidemic. *Health Secur* 2019;17:193–9.
- [22] Rivadeneira MF, Bassanesi SL, Fuchs SC. Socioeconomic inequalities and measles immunization coverage in Ecuador: a spatial analysis. *Vaccine* 2018;36:5251–7.
- [23] Qazi SH, Masoud S, Usmani MA. Vaccine hesitancy: acceptance of COVID-19 vaccine in Pakistan. *Clin Exp Vaccine Res* 2023;12:209–15.
- [24] Rosen JB, Arciuolo RJ, Khawja AM, *et al.* Public health consequences of a 2013 measles outbreak in New York City. *JAMA Pediatrics* 2018;172:811–7.
- [25] Rechel B, Roberts B, Richardson E, *et al.* Health and health systems in the Commonwealth of Independent States. *Lancet* 2013;381:1145–55.
- [26] Media Max. Immunization: Caring for children at-risk. MediaMax [Internet]. Accessed 13 May 2024. <https://mediamax.am/en/news/society/51241>
- [27] Turaiche M, Grigoras ML, Bratosin F, *et al.* Disease progression, clinical features, and risk factors for pneumonia in unvaccinated children and adolescents with measles: a re-emerging disease in Romania. *Int J Environ Res Public Health* 2022;19:Article 20.
- [28] Wang R, Jing W, Liu M, *et al.* Trends of the global, regional, and national incidence of measles, vaccine coverage, and risk factors in 204 countries from 1990 to 2019. *Front Med* 2022;8:798031.
- [29] Comprehensive Multi-Year Plan of the National Immunization Programme of Armenia 2011-2015 [WHO]. Accessed 13 May 2024. https://extranet.who.int/countryplanningcycles/sites/default/files/country_docs/Armenia/arm-cmyp-english-2011-2015_final_1705.pdf.
- [30] RVF. Measles Eradication and CRS Prevention in Armenia – RVF [Internet]. Accessed 13 May 2024. <https://rostopovich.org/en/measles-eradication-crs-prevention-in-armenia/>
- [31] Griffin DE. Measles vaccine. *Viral Immunol* 2018;31:86–95.
- [32] Sudfeld CR, Navar AM, Halsey NA. Effectiveness of measles vaccination and vitamin A treatment. *Int J Epidemiol* 2010;39(suppl_1):i48–55.
- [33] Awotiwoon AA, Oduwole O, Sinha A, *et al.* Zinc supplementation for the treatment of measles in children. *Cochrane Database Syst Rev* 2017;6:CD011177.