Original Research

# Factors influencing the unexpected measles outbreak of 2023 in Colombo, Sri Lanka

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## Abstract

**Introduction:** Measles, a highly contagious viral disease remains a significant global public health concern. The resurgence of measles outbreak in 2023 ended the four-year measles-free status in Sri Lanka initially achieved in 2019.

**Objectives:** To examine the risk factors contributing to the unexpected outbreak in the Colombo Regional Director of Health Services (RDHS) area and offer recommendations for public health implications

**Methods:** A cross-sectional study was conducted among all 142 notified cases of fever and maculopapular rash reported for one-year from 1 January 2023 in Colombo RDHS area. Cases were confirmed based on serological, virological, clinical or epidemiological criteria, with incomplete data revisited to ensure accuracy. Information on demographic data, vaccination status, and contact history was collected. Odds ratio (OR) with 95% confidence interval (CI) was calculated to identify risk factors, and multiple logistic regression was performed to adjust for confounders. A p-value of less than 0.05 was considered statistically significant.

**Results:** Of the 142 notified cases of fever and maculopapular rash, 113 were confirmed as measles (79.6%). Of the confirmed cases, 80 (70.8%) were confirmed through blood, throat, or nasal swab testing, 33 (29.2%) were clinically confirmed, and 2 (1.8%) were confirmed based on epidemiological criteria. Among the confirmed cases, 48.7% (n=55) were aged between 3-15 years, and 55.8% (n=63) were female. The highest proportion of cases was identified within the Muslim population (53.1%). A majority (n=92; 81.4%) of confirmed cases were unvaccinated. A history of contact with infected individuals significantly increased the risk of measles (OR=7.50; 95% CI: 2.10-14.4; p=0.002). Children aged 3 years or younger exhibited a lower risk (OR=0.41; 95% CI: 0.25-0.68; p=0.001), while vaccination demonstrated strong protection against infection (OR=16.61; 95% CI: 3.38-20.48; p=0.001). Contact history (adjusted OR=8.46) and non/partial vaccination (adjusted OR=6.61) were the strongest predictors of infection.

**Conclusions & Recommendations:** Measles outbreak in 2023 was predominantly driven by unvaccinated individuals and contact with infected cases. To prevent future outbreaks and enhance immunization coverage, targeted catch-up immunization campaigns focusing on high-risk groups, alongside culturally sensitive educational initiatives are urgently required.

***Keywords:*** *contagious disease, measles outbreak, measles IgM, post-elimination status*

## Introduction

Measles is a highly contagious viral infection transmitted primarily through airborne droplets from coughing and sneezing or through close contact with nasal or throat secretions of an infected individual (1). With a basic reproduction number ($R_0$) ranging from 12 to 18, the virus can infect approximately 90% of susceptible individuals upon exposure, making measles one of the highly contagious diseases. While measles is typically a mild illness, it can develop into a severe acute condition with serious long-term health consequences, particularly in children under 5 and adults over 30, with the risks significantly higher among malnourished children or those with weakened immune systems (1). Initial symptoms typically include fever, cough, runny nose, and conjunctivitis, followed by the appearance of a characteristic non-vesicular maculopapular rash. Severe complications such as ear infections, pneumonia and diarrhoea are especially common in young children and those with compromised immune systems. In rare cases, measles can lead to brain inflammation, resulting in progressive neurological deterioration or even death, despite supportive treatment. Another rare complication is subacute sclerosing panencephalitis (SSPE), a fatal neurological disorder affecting approximately 1 in 1,000 children who contract measles (2).

The introduction of effective vaccines, particularly the combined measles, mumps and rubella (MMR) vaccine, offered hope for the global elimination of measles in early 1990s. However, misinformation and a lack of trust in healthcare systems in certain regions, including falsely linking the MMR vaccine to autism (3), hindered progress globally. Although these claims were thoroughly discredited by extensive research, their impact eroded public confidence in vaccines, leading to declining vaccination rates in some countries (4). In Sri Lanka, immunization coverage has consistently remained high, exceeding 95% for all Expanded Programme of Immunization (EPI) vaccines, even during the COVID-19 pandemic. In 2023, vaccination achieved 99% coverage for both doses of MMR vaccine, reaffirming its role as the most effective method for preventing measles (5). Despite this strong national performance, localized pockets of low vaccination coverage exist, often influenced by socioeconomic challenges (6). These areas of vulnerability highlight the need for targeted interventions to prevent outbreaks in otherwise well-covered populations.

Sri Lanka has been experiencing measles outbreak since May 2023, primarily affecting unvaccinated children, with the highest incidence reported in the Colombo district (6). Key contributing factors include persistent vaccine hesitancy and insufficient public awareness of the disease severity, which have resulted in clusters of unvaccinated individuals (7). Identifying high-risk groups and tailoring health education programs to address their specific needs is therefore essential.

## Methods

A cross-sectional descriptive study was conducted using secondary data derived from the 'Surveillance of Measles-Case Investigation Forms' submitted to the Regional Epidemiology Unit of the Regional Director of Health Services (RDHS), Colombo by medical officers of health (MOH) from January 1 to December 31, 2023. To ensure data completeness and validity, incomplete records were revisited with respective MOH. Active case finding in the communities was conducted for each reported case, encompassing nearest 30–50 households or within a 1 km radius, to identify additional clinically suspected cases of measles (8).

Confirmed cases were identified through testing blood samples (between the 3$^{rd}$ and 28$^{th}$ day after the appearance of rash) for anti-measles IgM antibodies or testing throat or nasal swabs for viral RNA using RT-PCR (within the first five days of the rash) at the National Reference Laboratory of the Medical Research Institute (8). If laboratory confirmation is not feasible or delayed, cases may be classified based

on clinical presentation or epidemiological linkage. Clinically confirmed cases were defined as those presenting with "fever and maculopapular rash accompanied by at least one of the following: cough, coryza, or conjunctivitis" (9). Cases with a direct epidemiological link to a confirmed case within 7–21 days of exposure were classified as epidemiologically confirmed cases (10).

***Data analysis***

Data were extracted using a form capturing demographic and clinical details. Frequencies and proportions were calculated to describe the epidemiological characteristics. Odds ratios (OR) and 95% confidence interval (CI) were computed to assess the strength of association between risk factors and measles infection. Multiple logistic regression was carried out adjusted for potential confounders, with adjusted OR (aOR) and a p-value of less than 0.05 considered statistically significant. As this study involved the use of secondary data that had been anonymized to protect individual identities, ethical clearance was not obtained.

## Results

In 2023, a total of 142 fever and maculopapular rash cases were reported to the RDHS Colombo. Of these, 113 (79.6%) were confirmed as measles. Most (70.8%) were confirmed through serological or virological testing, while 29.2% were confirmed clinically and 1.8% were confirmed epidemiologically. Among the confirmed cases, 48.7% were aged 3-15 years and 55.8% were female.

The ethnic distribution of confirmed cases revealed that 53.1% were Muslim (Table 1). The outbreak peaked in August and September 2023, accounting for 21.1% (n=30) and 22.5% (n=32) of cases, respectively (Figure 1). Most confirmed cases were unvaccinated (85.8%), while 12.4% had received a single dose of measles-containing vaccine (MCV) and 1.8% two doses. Additionally, 72.6% of confirmed cases reported a contact history of measles (Table 2). Among unvaccinated individuals, the 3 to 15 years represent the highest (53.8%).

**Table 1: Socio-demographic and geographic data of the suspected individuals (N=142)**

| Characteristics | Confirmed cases, No. (%) | | Negative (n=29) | Total |
|---|---|---|---|---|
| | Serological and virological (n=80) | Clinically and epidemiological (n=33) | | |
| **Age** | | | | |
| Less than 9 months | 10 (12.5) | 5 (15.2) | 3 (10.3) | 18 (12.7) |
| 9 months - 3 years | 14 (17.5) | 6 (18.2) | 3 (10.3) | 23 (16.2) |
| 3 - 15 years | 40 (50.0) | 15 (45.5) | 8 (27.6) | 63 (44.4) |
| 15 - 30 years | 14 (17.5) | 5 (15.2) | 11 (37.9) | 30 (21.1) |
| More than 30 years | 2 (2.5) | 5 (15.2) | 4 (13.8) | 8 (5.6) |
| **Gender** | | | | |
| Male | 35 (43.8) | 15 (45.5) | 13 (44.8) | 63 (44.4) |
| Female | 45 (56.2) | 18 (54.5) | 16 (55.2) | 79 (55.6) |
| **Ethnicity** | | | | |
| Muslim | 40 (50.0) | 20 (60.6) | 12 (41.4) | 72 (50.7) |
| Sinhala | 30 (37.5) | 10 (30.3) | 8 (27.6) | 48 (33.8) |
| Tamil | 10 (12.5) | 3 (9.1) | 9 (31.0) | 22 (15.5) |

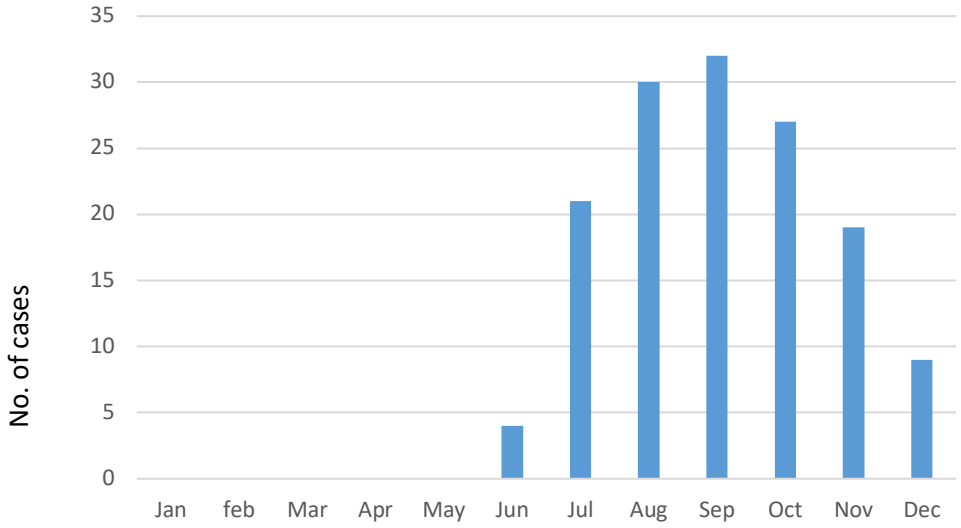


***Figure 1: Monthly distribution of fever and rash cases reported to RDHS, Colombo in 2023***

**Table 2: Vaccination status and contact history of individuals (N=142)**

| Characteristics | Confirmed cases, No. (%) | | Negative (n=29) | Total |
|---|---|---|---|---|
| | Serological and virological (n=80) | Clinically and epidemiological (n=33) | | |
| **Vaccination status** | | | | |
| Unvaccinated | 72 (90.0) | 20 (60.6) | 12 (41.4) | 104 (73.2) |
| Single dose of MCV | 2 (2.5) | 2 (6.1) | 4 (13.8) | 8 (5.6) |
| Two doses of MCV | 1 (1.3) | 1 (3.0) | 10 (34.5) | 12 (8.5) |
| Not eligible for vaccination | 5 (6.2) | 10 (30.3) | 3 (10.3) | 18 (12.7) |
| **Contact history** | | | | |
| Present | 65 (81.3) | 27 (81.8) | 10 (34.5) | 102 (71.8) |
| Absent | 15 (18.8) | 6 (18.2) | 19 (65.5) | 40 (28.2) |

**Table 3: Risk factors associated with measles infection**

| Risk factor | Odds ratio (OR) | 95% CI | P-value |
|---|---|---|---|
| Age: 3 years or less | 0.41 | 0.25-0.68 | **0.001** |
| Gender: Male | 0.8 | 0.41-1.5 | 0.43 |
| Contact history: Present | 8.32 | 2.1-14.4 | **0.002** |
| Missed doses of MCV | | | |
| Single dose | 2.67 | 0.98-3.01 | 0.55 |
| Two doses | 38.33 | 28.49-59.67 | **<0.001** |
| Ethnicity: Muslim | 1.6 | 0.7-3.67 | 0.26 |

Reference categories: Age above 3 years, female gender, absence of contact history with measles cases, vaccination with MCV according to EPI, and ethnicity other than Muslim

The analysis of measles risk factors revealed that children aged 3 years or younger had a significantly lower risk of infection (OR=0.41; 95% CI: 0.25-0.68) compared to older children. Male gender showed no significant association with measles risk (OR=0.8; 95% CI: 0.41-1.5). Unvaccinated individuals had a significantly higher risk of contracting measles compared to those who received two doses of the vaccine (OR=38.33; 95% CI: 28.49-59.67). Muslim ethnicity did not show a significant difference in risk (OR=1.6; 95% CI: 0.7-3.67). Contact with a measles case was a strong predictor of infection (OR=8.32; 95% CI: 2.1-14.4) (Table 3).

The adjusted analysis of risk factors showed that males had a slightly higher, but not significant, risk of measles compared to females (aOR=1.45; 95% CI: 0.73-2.89). Individuals who had contact with a measles case were at a significantly higher risk (aOR=8.46; 95% CI: 2.08-34.41). Additionally, un-vaccination greatly increased the risk of contracting measles (aOR=6.61; 95% CI: 2.6-16.82) (Table 4).

**Table 4: Risk factors associated with measles infection adjusted for covariates**

| Risk factor | Adjusted OR | 95% CI | P-value |
|---|---|---|---|
| Gender: Male | 1.45 | 0.73-2.89 | 0.290 |
| Age: 3 years or less | 0.95 | 0.92-1.99 | 0.060 |
| Contact history: Present | 8.46 | 2.08-34.41 | **0.003** |
| Missed single or both doses of MCV: Yes | 6.61 | 2.60-16.82 | **0.001** |
| Ethnicity: Muslim | 1.22 | 0.78-1.98 | 0.563 |

Reference categories: Female gender, age above 3 years, absence of contact history with measles cases, vaccination with MCV according to EPI , and ethnicity other than Muslim

## Discussion

The detection of the first laboratory-confirmed measles case in the Colombo Municipal Council area in late May 2023 marked the resurgence of the disease in Sri Lanka, highlighting critical gaps in vaccination coverage **(**11). The outbreak subsequently spread to several parts of the Colombo district. Cases with positive contact histories were later reported, indicating that the outbreak initially propagated among unvaccinated individuals before spreading to other vulnerable groups in the community.

The high proportion of measles-positive cases among children aged 3-15 years (48.7%) can be attributed to several key factors. This age group also represents the highest proportion of unvaccinated individuals (53.8%) in our study. Incomplete immunization, often due to missed doses of the MCV, is a significant risk factor, leaving many children vulnerable to the virus. Additionally, children in this age group frequently in school or engage in social activities, which increase their exposure to others and facilitating the spread of disease. Further, two children have received only one dose of the vaccine in our study, which may not confer immunity, as approximately 10-15% of children vaccinated at 9 months may fail to seroconvert. Although the measles vaccine is one of the most effective and safest vaccines available, with 97% effectiveness after two doses, the second dose is crucial to ensure immunity for those who did not respond to the first dose, thus strengthening population-level protection and providing long-term immunity that typically lasts a lifetime and rarely causes serious adverse events (8). Therefore, along with district and national health authorities, the MOHs should closely monitor vaccination coverage and address gaps in immunization to prevent a potential outbreak.

Among the 113 confirmed measles cases, 15 (13.3%) were infants under the age of 9 months, a group

particularly vulnerable due to waning of maternal antibodies, which usually provide early protection. With widespread immunization, natural measles infections had become rare due to that most mothers acquired immunity through vaccination rather than natural exposure. As a result, the maternal antibodies transferred to the foetus may not have been sufficient to protect the infants from measles, leaving them more susceptible to infection (8). In the 9-month to 3-year age group, the timing of seroconversion and susceptibility to measles requires further investigation. The first dose of MMR vaccine is administered at 9 months, coinciding with the waning of maternal antibodies. These antibodies can interfere with the immune response to the vaccine if administered too early, potentially delaying or weakening seroconversion. Therefore, infants aged 9-12 months remain at risk if exposed to the virus before achieving immunity (12).

In response to this outbreak, a supplementary immunization activity (SIA) targeting infants aged 6-9 months was carried out in 2024 in nine high-risk districts (8). While seroconversion usually occurs within 10 to 14 days post-vaccination, individual immune response can vary based on factors like malnutrition or concurrent infections, affecting the development of immunity. This emphasizes the importance of timely and complete vaccination to ensure protection against measles. Immunization remains the most reliable method to prevent measles, with the measles vaccine achieving a success rate of at least 95% and seroconversion rates approaching 100%. In endemic areas, the first dose of MCV is typically administered at nine months, followed by a second dose around the third year of age (13). This highlights the need for targeted public health interventions to identify and immunize children who may have missed their first or second dose (14).

In our study, the adjusted analysis of measles risk factors indicated that males had a slightly higher, but not statistically significant, risk of measles compared to females (aOR=1.45; 95% CI: 0.73-2.89). While this finding may reflect a true but minor gender-related difference, it could also be influenced by selection bias, as health-seeking behaviour may be more prevalent among males for illnesses. For instance, the study relied on notified cases from specific healthcare facilities, which might not fully represent the population at risk. Further population-based research is needed to confirm or refute this observation and to minimize potential biases. These findings highlight the importance of ensuring representative sampling in future studies to enhance the generalizability of results.

In our study, 53.1% of the confirmed measles cases in 2023 were from Muslim ethnic community. Several factors, including lack of knowledge, perceptions, and beliefs about vaccines, have contributed to parents not vaccinating their children routinely (15). Positive vaccine attitudes, encompassing knowledge and awareness of vaccination, trust in vaccine effectiveness, and supportive religious beliefs, were identified. Conversely, negative vaccine attitudes included doubts about vaccine efficacy and safety, personal beliefs regarding vaccine sources, and religious misconceptions. Additionally, negative influences like the perception of vaccine risks spread through word-of-mouth, reliance on personal opinions over scientific evidence, and self-interpreted religious views also played a role in vaccine refusal. Previous studies have highlighted these factors, but a more detailed and in-depth investigation into perceptions and beliefs is needed to better understand the true causes of vaccine hesitancy in this community (16-17).

The outbreak reached its peak in August and September 2023. However, due to the high overall immunization coverage against measles and the implementation of outbreak response strategies such as enhanced case-based surveillance and field-level mitigation efforts, it was possible to control the spread and limit the number of cases. These efforts were consistent with national trends observed during this period (14).

Vaccination provides significant protection against measles, with vaccinated individuals having an approximately 85% reduced risk of infection compared to those unvaccinated (OR=6.1; 95% CI: 2.5-14.2). Furthermore, individuals who have not been vaccinated are at substantially higher risk of contracting the virus (adjusted OR=6.61; 95% CI: 2.6-16.82). This result aligns with the theoretically calculated vaccine-preventable fraction, which demonstrated an 87% protective efficacy when an individual receives a single dose of the MCV at 9 months of age (18). This finding is also consistent with other studies, which have shown that vaccinated individuals are at a lower risk of contracting measles (19).

The study also revealed that individuals with a contact history of measles 2–3 weeks before developing the current infection had a 9-fold risk of contracting measles compared to those without known contact during the same period. This finding is in line with research conducted in Ethiopia, where susceptible individuals with a contact history were found to have a higher likelihood of acquiring measles compared to those without (20). This highlights the importance of early identification and isolation of measles cases to prevent further spread, particularly among vulnerable populations, such as those who have not been vaccinated or are under-vaccinated.

One limitation of this study is the use of retrospective data from secondary sources, which can limit the generalizability of the findings due to potential inaccuracies or incompleteness in the records. Additionally, the study may be subject to recall bias, as individuals may not accurately report their vaccination status or contact history with measles cases. Another important limitation is the potential influence of unmeasured confounding factors, such as socioeconomic status, access to healthcare, nutritional status, and community-level vaccination coverage. These variables could affect both the risk of measles infection and the likelihood of detection or reporting, thereby influencing the observed associations. Furthermore, the study focused on a specific geographic area, which may not fully represent the situation in other regions. Lastly, the reliance on reported cases might underestimate the true extent of the outbreak, as mild or asymptomatic cases could go undetected.

## Conclusions & Recommendations

This study highlights the critical importance of immunization in preventing measles. The 2023 measles outbreak in Sri Lanka highlights the vulnerability of under-vaccinated individuals, especially those with known contact histories. To mitigate the risk of further outbreaks, it is essential to strengthen vaccination campaigns and improve surveillance systems. Additionally, enhancing public health education to address vaccine hesitancy and ensuring timely and complete vaccination will be vital in preventing future measles cases. Targeted immunization efforts in high-risk areas should be prioritized to maintain herd immunity and control the spread of virus.

### Public Health Implications

- Public health staff must strengthen efforts to monitor and ensure vaccination coverage, especially in high-risk areas and among vulnerable populations. It is crucial to enhance surveillance systems, ensure timely identification and isolation of measles cases, and improve data collection to prevent further outbreaks.
- Additionally, public health teams should prioritize raising awareness and addressing vaccine hesitancy through targeted education, outreach, and interventions, fostering broader immunity and reducing the risk of future measles transmission.

## Author Declarations

***Competing interests:*** The authors declare that they have no competing interests.

***Ethics approval and consent to participate:*** Ethical approval was not obtained for this study.

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***Author contributions:*** KK led the writing of the manuscript; KK managed data collection, contributed to data analysis, figure creation, and drafting the methods section; Both authors contributed to the study's design and coordination, verified the accuracy of the results and critical revision of the manuscript; and CG provided feedback on the methods and reviewed the preliminary findings.

## References

1. World Health Organization. *Measles.* Available from: https://www.who.int/news-room/fact-sheets/detail/measles. Accessed 10 December 2024.
2. Blutinger E, Schmitz G, Kang C, Comp G, Wagner E, Finnell JT, Cozzi N, Haddock A. Measles: Contemporary considerations for the emergency physician. *J Am Coll Emerg Physicians Open* 2023; 4(5): e13032. https://doi.org/10.1002/emp2.13032.
3. Rodriguez-Nava G, Trelles-Garcia DP, Yanez-Bello MA, Imani-Ramos T, Trelles-Garcia VP, Bustamante-Soliz DS, et al. MMR vaccine adverse drug reactions reports in the CDC WONDER system, 1989–2019. *Open Forum Infect Dis* 2020; 7(8): ofaa211. https://doi: 10.1093/ofid/ofaa211
4. Guerra FM, Bolotin S, Lim G, Heffernan J, Deeks SL, Li Y, Crowcroft NS. The basic reproduction number ($R_0$) of measles: a systematic review. *Lancet Infect Dis* 2017; 17(12): e420-8. https://doi.org/10.1016/S1473-3099(17)30307-9.
5. World Health Organization. *Immunization Dashboard Sri Lanka.* Available on: https://immunizationdata.who.int/dashboard/regions/south-east-asia-region/LKA. Accessed 10 December 2024.
6. Epidemiology Unit. *MMR Catch-up Immunization Programme.* Colombo: Ministry of Health. Available from: https://www.epid.gov.lk/mmr-catch-up-immunization-programme#:~:text=Adding%20to%20this%20global%20challenge,9%20months%20%2D%203%20years. Accessed 10 December 2024.
7. Wilder-Smith AB & Qureshi K. Resurgence of measles in Europe: a systematic review on parental attitudes and beliefs of measles vaccine. *J Epidemiol Glob Health* 2020; 10(1): 46-58. https://doi.org/10.2991/jegh.k.191117.001.
8. Liyanapathirana A. Revisiting measles in Sri Lanka: an epidemiological overview. *J Coll Community Physicians Sri Lanka* 2024; 30(1): 3-7. https://doi.org/10.4038/jccpsl.v30i1.8712.
9. Epidemiology Unit. Surveillance of measles. Ministry of Health, Sri Lanka**.** *Quarterly Epidemiological Bulletin: First Quarter 2023*. Available from: https://www.epid.gov.lk/storage/post/pdfs/en_66a36e38ddcd7_2023%20QEB%201.pdf.
10. UK Health Security Agency. *National Measles Guideline.* Available from: https://assets.publishing.service.gov.uk/media/66a0ce1449b9c0597fdb03a6/20240704_national-measles-guidelines-July-2024.pdf. Accessed 10 December 2024.
11. Fernando MA, Chathuranga GP, Abeygunasekara KG, Weligamage DD, Abeynayake JI. Resurgence of measles virus infection in an eliminated country, Sri Lanka. *Asian Pac J Trop Med* 2024; 17(5): 208-213. https://doi.org/10.4103/apjtm.apjtm_182_24.
12. ISIK N, Uzel N, Gökçay G, Kilic A, Yilmaz G, Sadikoglu B, Diri S. Seroconversion after measles vaccination at nine and fifteen months of age. *Pediatr Infect Dis J* 2003; 22(8): 691-695. https://doi.org/10.1097/01.inf.0000078158.23337.ed.
13. European Centre for Disease Prevention and Control. *Fact Sheet about Measles.* Available from: https://www.ecdc.europa.eu/en/measles/facts. Accessed 10 December 2024.

14. MSF medical guidelines. *Measles Vaccine.* Available from: https://medicalguidelines.msf.org/en/viewport/mme/english/2-1-measles-vaccine-32407628.html. Accessed 8 December 2024.

15. Smith LE, Amlôt R, Weinman J, Yiend J, Rubin GJ. A systematic review of factors affecting vaccine uptake in young children. *Vaccine* 2017; 35(45): 6059-6069. https://doi.org/10.1016/j.vaccine.2017.09.046.

16. Jinarong T, Chootong R, Vichitkunakorn P, Songwathana P. Muslim parents' beliefs and factors influencing complete immunization of children aged 0–5 years in a Thai rural community: a qualitative study. *BMC Public Health* 2023; 23(1): 1348. https://doi.org/10.1186/s12889-023-15273-y.

17. McKee C, Bohannon K. Exploring the reasons behind parental refusal of vaccines. *J Pediatr Pharmacol Ther* 2016; 21(2): 104-109. https://doi.org/10.5863/1551-6776-21.2.104.

18. Kaninda AV, Legros D, Jataou IM, Malfait P, Maisonneuve M, Paquet C, Moren A. Measles vaccine effectiveness in standard and early immunization strategies, Niger, 1995. *Pediatr Infect Dis J* 1998; 17(11): 1034-1039.

19. Fragkou PC, Thomas K, Sympardi S, Liatsos GD, Pirounaki M, et al. Clinical characteristics and outcomes of measles outbreak in adults: A multicentre retrospective observational study of 93 hospitalized adults in Greece. *J Clin Virol* 2020; 131: 104608. https://doi.org/10.1016/j.jcv.2020.104608.

20. Shimelis Y, Asrat A, Tadege T, Feleke SF. Measles outbreak investigation in Berhet District, North Shewa, Ethiopia. *Front Public Health* 2024; 12: 1330205. https://doi.org/10.3389/fpubh.2024.1330205.