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Factors Associated with Measles Infection in Dak Lak Province, Vietnam, 2024–2025

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Abstract: Background: Measles outbreaks have continued to occur in several localities despite high vaccination coverage, suggesting that certain risk factors still contribute to disease transmission. Objective: To analyze some factors associated with measles infection in Dak Lak Province, Vietnam, during 2024–2025. Methods: A cross-sectional analytical study was conducted using epidemiological surveillance data. The analyzed factors included sex, age group, area of residence, vaccination history, exposure, and travel history. Associations were examined using odds ratios (ORs) with 95% confidence intervals (CIs). Results: The risk of measles infection was higher among unvaccinated individuals, those with a history of contact with confirmed cases, those who had traveled within three weeks before disease onset, and those residing in outbreak areas compared with other groups. Multivariate analysis indicated that incomplete vaccination and exposure history were the principal risk factors. Conclusion: Incomplete vaccination and close contact with measles cases were identified as the leading risk factors. Strengthening vaccination coverage, improving contact surveillance, and implementing early community interventions are necessary to reduce outbreaks.

Keywords: Measles, risk factors, vaccination, epidemiology, Dak Lak

INTRODUCTION

Measles is an acute infectious disease caused by the measles virus, transmitted via respiratory droplets or close contact with secretions from the nose and throat of infected individuals. It remains one of the leading causes of mortality in young children due to immune suppression and complications such as pneumonia and acute respiratory failure in unvaccinated cases (Ministry of Health. 2025). According to the World Health Organization (WHO), before the introduction of measles vaccines, approximately 90% of children under 10 years of age contracted measles, and in 2001 an estimated 23 million people worldwide suffered from its consequences (World Health Organization, 2009).

In Vietnam, measles outbreaks have continued to occur with major epidemics reported in 2009–2010, 2013–2014, 2018–2019, and most recently in 2024–2025. National studies have shown that most cases occurred among unvaccinated or incompletely vaccinated children, particularly in those under 9 months of age, who are not yet eligible for vaccination (Huyen, D. T. T. & Hong, D. T. 2016). In Dak Lak Province, the measles vaccination program has been implemented since 1983, with annual coverage rates reported at over 90%. Nevertheless, recurrent outbreaks have been documented: 102 cases in 2014, 50 cases in 2018, 387 confirmed cases in 2019, and 898 confirmed cases in 2024 out of 1,243 rash-fever cases reported (Ministry of Health, 2012). These figures highlight the persistence of a susceptible population and the presence of local risk factors.

Both national and international studies have indicated that factors strongly associated with measles infection include vaccination status, age group, history of exposure, travel, area of residence, and immune status (World Health Organization, 2009; Hang, N. M. 2018).

Based on this context, the present study was conducted with the objective of "Analyzing factors associated with measles infection in Dak Lak Province, Vietnam, during 2024–2025." The findings aim to provide scientific evidence to strengthen epidemiological surveillance, support immunization programs, and contribute to the control and eventual elimination of measles at the local level.

MATERIALS AND METHODS

Study Subjects

The study population included cases of suspected measles and laboratory-confirmed measles reported through the epidemiological surveillance system in Dak Lak Province from January 1, 2024, to June 30, 2025.

Inclusion criteria:

- *Suspected case:* any individual with fever and rash accompanied by at least one of the following symptoms: cough, coryza, or conjunctivitis (Ministry of Health, 2012).
- *Confirmed case:* a suspected case with positive serological IgM or RT-PCR test results for measles virus (Ministry of Health. 2025).

Exclusion criteria: Cases of rash and fever confirmed to be caused by rubella or other etiologies.

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Study period and setting

- *Period:* from January 2024 to June 2025.
- *Setting:* Dak Lak Province, including 15 districts, towns, and the provincial city.

Study design

An analytical cross-sectional study was conducted using measles case surveillance data and epidemiological investigation reports collected by the Dak Lak Provincial Center for Disease Control (CDC).

Sample size and sampling method

All suspected measles cases reported in the surveillance system during the study period were included in the analysis (n = 2,950 cases), of which 1,273 were laboratory-confirmed measles cases.

Data collection

Secondary data sources included:

- Epidemiological surveillance reports of measles cases from Dak Lak CDC.
- Laboratory test results (ELISA IgM/IgG and RT-PCR) of suspected cases.
- Standardized epidemiological investigation forms for measles cases issued by the Ministry of Health.

Data Analysis

- Data were entered and processed using SPSS version 22.0.
- *Descriptive statistics:* frequencies and percentages were calculated.
- *Analytical statistics:* the χ^2 test was applied to assess associations between potential risk factors and measles infection. Odds ratios (ORs) with 95% confidence intervals (95% CIs) were estimated.
- *Multivariate analysis:* logistic regression was performed to identify independent risk factors.

Ethical Considerations

This study used surveillance data without direct intervention on patients. Personal information was coded and kept confidential in accordance with the Ministry of Health regulations. The study protocol was reviewed and approved by the Scientific and Ethical Committee of the Dak Lak Provincial Department of Health.

RESULTS

Case classification of measles

Table 1. Surveillance results of suspected measles cases in Dak Lak Province, 2024–2025

Year	Total suspected measles cases	Samples collected for testing		Results on Measles Cases		
		n	(%)	Positive (%)	Negative (%)	Indete (%)
2024	1,243	1.236	99.4	898 (72.7)	303 (24.5)	35 (2.8)
2025(*)	1,707	478	28.0	375 (78.4)	95 (19.9)	8 (1.7)
Total	**2,950**	**1.714**	**58.1**	**1,273 (74.3)**	**398 (23.2)**	**43 (2.5)**

Data up to June 30, 2025.

Out of 2,950 suspected measles cases with rash and fever, 1,714 (58.1%) were sampled for laboratory testing. A total of 1,273 cases (74.3%) were laboratory-confirmed measles, 23.2% were negative, and 2.5% remained indeterminate. As of June 30, 2025, the number of suspected measles cases had increased to 1,707 (an approximate 37% increase compared with 2024). However, the proportion of cases tested decreased to 28.0%. Despite this decline, the proportion of positive cases among those tested increased to 78.4% (375/478).

Factors Associated with Measles Incidence

Table 2. Factors associated with measles incidence

Variables	Samples collected for testing	*Measles* (n=1,273)		OR (CI 95%)	p
		Positive (%)	Negative (%)		
Sex					
Male	902	660 (73.2)	242 (26.8)	0.86 (0.71-1.11)	0.3
Female	813	613 (75.5)	199 (24.5)		
Age group					
0 - 8 months	299	212 (70.9)	87 (29.1)	Reference	
9 - 11 months	150	106 (70.7)	44 (29.3)	1.10 (0.66 – 1.56)	1

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1 - 4 years	597	451 (75.5)	146 (24.5)	0.79 (0.58 – 1.08)	0.18
5 - 9 years	306	238 (77.8)	68 (22.2)	0,70 (0.48 – 1.01)	0.65
10 - 14 years	184	137 (74.5)	47 (25.5)	0.84 (0.55 – 1.27)	0.46
≥ 15 years	178	129 (72.5)	49 (27.5)	0.93 (0.61 – 1.40)	0.79
Residential area					
Urban	508	379 (74.6)	129 (25.4)	1.03 (0.80-1.31)	0.88
Rural	1,206	894 (74.1)	312 (25.9)		
Number of measles vaccine doses received					
≥2 doses [(1)]	47	43 (91.5)	4 (8.5)	1.99 (0.61 – 8.45)	[(1)(2)] 0.33
1 dose [(2)]	128	108 (84.4)	20 (15.6)	2.61 (1.58 – 4.51)	[(2)(3)] 0.0001
No vaccination [(3)]	1,278	861 (67.4)	417 (32.6)	5.21 (1.87 – 20.0)	[(1)(3)] 0.0009
History of contact with a measles case					
No	1,138	875 (76.9)	263 (23.1)	Reference	
Yes	210	142 (67.6)	68 (32.4)	1.59 (1.14 – 2.22)	0.005
Unknown	366	256 (70.0)	110 (30.0)	1.43 (1.09 – 1.87)	0.009
Travel history within 3 weeks prior to disease onset					
No	1,299	991 (76.3)	308 (23.7)	Reference	
Yes	299	208 (69.6)	61 (30.4)	1.41 (1.05 – 1.87)	0.02
Unknown	116	74 (63.8)	42 (36.2)	1.83 (1.19 – 2.76)	0.004
Presence of rash–fever cases in residential area					
No	1,005	780 (77.6)	225 (22.4)	Reference	
Yes	194	132 (68.1)	62 (31.9)	1.63 (1.14 – 2.30)	0.006
Unknown	515	361 (70.1)	154 (29.9)	1.48 (1.15 – 1.89)	0.002

Analysis of several demographic and epidemiological factors showed the following associations with measles infection:

Sex: The incidence of measles was comparable between males (73.2%) and females (75.5%), with no statistically significant difference ($p = 0.3$).

Age group: Compared with infants aged 0–8 months, children aged 9–11 months had a 1.1-fold higher risk of measles, but this difference was not statistically significant ($p > 0.05$). Similarly, higher risks were observed in the 1–4, 5–9, 10–14, and ≥15 year age groups compared to the 0–8 month group; however, none of these differences reached statistical significance ($p > 0.05$).

Place of residence: The incidence rates in urban (74.6%) and rural (74.1%) areas were nearly identical, showing no significant difference ($p > 0.05$).

Number of measles vaccine doses: Individuals without vaccination had significantly higher risks of infection, being 2.61 times more likely compared with those receiving 1 dose, and 5.21 times compared with those receiving ≥2 doses ($p < 0.05$). The risk among individuals vaccinated with only 1 dose was 1.99 times higher than those with ≥2 doses, though this was not statistically significant ($p > 0.05$).

History of contact with measles cases: Individuals with contact history and those with unclear contact status had higher risks of infection, with ORs of 1.59 and 1.43 respectively, compared

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with those without contact. These differences were statistically significant ($p < 0.05$).

Travel history within 3 weeks prior to onset: Individuals who had traveled and those with unclear travel history had significantly increased risks, with ORs of 1.41 and 1.83, respectively, compared to those without travel history ($p < 0.05$).

Presence of rash cases in residential area: Living in areas with suspected rash/fever cases or with unknown status was associated with a higher risk of measles compared with living in areas without such cases, with statistically significant differences ($p < 0.05$).

Multivariate logistic regression analysis of factors associated with measles infection

Table 3. Multivariate logistic regression model of factors associated with measles infection

Factor	OR	95%CI	p
Sex (male/female)	1.09	0.87 – 1.36	0.77
Residential area (urban/rural)	0.85	0.67 – 1.09	0.21
Vaccination status (1 dose/none)	2.00	1.20 – 3.34	0.008
Vaccination status (≥2 doses/none)	3.78	1.34 – 10.68	0.012
History of contact with measles case (yes/no)	1.68	1.21 – 2.33	0.002
Travel history within 3 weeks prior to onset (yes/no)	1.39	1.05 – 1.84	0.022
Presence of rash cases in residential area (yes/no)	1.53	1.09 – 2.16	0.015

To assess the independent effects of each factor on measles infection, a multivariate logistic regression model was applied. The analysis revealed that the following factors were significantly associated with the risk of measles infection:

Measles vaccination was a strong protective factor. Individuals who received **one dose** had a twofold reduction in risk compared with those unvaccinated ($p = 0.008$), whereas those who received **≥2 doses** had up to a 3.78-fold reduction in risk ($p = 0.012$). These findings confirm the protective effectiveness of measles vaccine, particularly when the full ≥2-dose schedule is completed.

History of contact with measles cases was a strong risk factor, increasing the likelihood of infection by 1.68 times ($p = 0.002$). This is highly consistent with the transmission mechanism of measles through close contact.

Presence of rash cases in the residential area was associated with a 1.39-fold higher risk of measles infection, which was statistically significant ($p = 0.015$).

Travel history within three weeks prior to disease onset also increased the risk of measles infection by 1.53 times, with statistical significance ($p = 0.022$).

DISCUSSION

Case classification of measles

The study findings showed that in 2024, a total of 1,243 suspected measles rash cases were reported, of which 99.4% were sampled and 72.7% tested positive for measles virus. During the first six months of 2025, the number of suspected measles rash cases increased to 1,707, but only 478 cases (28.0%) were sampled, although the positivity rate was higher (78.4%). These results confirm that measles virus continues to circulate actively in the community.

The proportion of negative samples ranged from 19.9% to 24.5%, reflecting the presence of other viral pathogens responsible for febrile rash syndromes. Approximately 2–3% of samples were classified as "suspected," mainly due to technical limitations: samples collected either too early or too late in relation to rash onset, or inadequate storage conditions. This underscores the critical role of laboratory testing not only in confirming measles cases but also in identifying alternative causes of febrile rash.

In 2024, the proportion of laboratory-confirmed cases was very high (99.4%). However, in the first half of 2025, this proportion dropped markedly to 28.0%, and no cases were diagnosed based on epidemiological linkage. The main reason was the incomplete collection of epidemiological contact information in case investigation forms and the limited utilization of these data. This represents a key limitation in the surveillance system, leading to overreliance on laboratory testing and excessive resource use.

In the context of increasing case numbers, a rational surveillance strategy should focus on laboratory confirmation for the index case and outbreak identification, while subsequent cases may be diagnosed based on epidemiological

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linkage. This approach ensures both effective outbreak detection and efficient use of laboratory resources.

Factors associated with measles incidence

The measles incidence rates between males (73.2%) and females (75.5%) were comparable, showing no statistically significant difference ($p > 0.05$). Our findings are consistent with the study by Mai Thi Phuoc Loan in Dak Lak in 2019 (Loan, M. T. P. 2020) and Do Phuong Anh's study on measles in Ha Long City during 2017–2021, which reported similar results (Loi, D. H. *et al.*, 2017). This indicates that measles infection is not influenced by sex, as the measles virus can affect any individual lacking immunity.

Data from Dak Lak during 2024–2025 showed that children aged 1–4 years accounted for the highest proportion of measles cases (35.4%). Overall, children under 5 years represented 60.3% of cases, similar to epidemiological studies conducted in Northern Vietnam (2009, 2014) (Yen, N. T. T. *et al.*, 2014) and in China during 2012–2013, which reported 68% of cases in this age group (Ma, C. 2015). This confirms that young children, particularly those under 5 years, remain the most vulnerable population in measles outbreaks. In our study, the 5–9 years age group accounted for only 18.7% of cases, one-third compared to children under 5, highlighting the declining trend in measles incidence with increasing age. This reflects the impact of the Expanded Program on Immunization (EPI), which has achieved substantial coverage in younger children, while many have also acquired natural immunity after infection. Among older age groups, measles incidence was more evenly distributed.

Analysis of geographic differences showed that children living in rural areas had a 1.03 times higher risk of measles compared to those in urban areas. This differs from the 2014 outbreak in Northern Vietnam, where Nguyen Minh Hang reported higher measles incidence in lowland provinces than in mountainous areas (Ministry of Health, 2012). This may be explained by the supplementary measles vaccination campaigns conducted after the 2014 outbreak, along with a large number of susceptible individuals in lowland regions having already acquired natural infection, leading to a shift in the susceptible pool toward mountainous areas.

Most measles cases had never received vaccination or had unknown vaccination status (71.6%). Our findings are consistent with the study by Nguyen Ngoc Sang at Hai Phong Children's Hospital in 2019 (69.82%) (Sang, N. N. 2022), and with Trinh Thi Hong Hanh's research in four provinces of the Central Highlands (Dak Lak, Dak Nong, Gia Lai, and Kon Tum) from January 2013 to August 2014, which reported 68.2% of measles cases unvaccinated, 54.0% with unknown vaccination history, 13.5% with one dose, and only 7.7% with two doses (Hanh, T. T. H. *et al.*, 2015). These results reconfirm the effectiveness of measles vaccination in preventing disease, showing that even a single dose provides considerable protection. However, our study did not find a statistically significant difference between one-dose and two-dose recipients. This can be explained by the high efficacy of the live attenuated measles vaccine, with the second dose primarily aimed at covering those who missed the first dose and providing another opportunity for seroconversion among those who did not respond to the initial vaccination.

Analysis of exposure history within 21 days before rash onset revealed a significant difference ($p < 0.05$): individuals with contact history had a 3.4-fold higher risk of measles compared to those without contact. This is consistent with findings from Northern Vietnam during 2013–2014 (OR 1.46) (Binh, N. V. 2015), although the risk observed in our study was higher. Given measles' airborne and close-contact transmission, thorough investigation of contact history is critical for outbreak containment and community health education. Once measles is confirmed, patients should limit social contact to reduce transmission risk.

Individuals with a travel history within 21 days prior to symptom onset had a 2.14-fold higher risk of contracting measles compared to non-travelers, with statistical significance. This aligns with the study by Tran Thi Minh Hue in Northern Vietnam (2013–2014) (Hue, T. T. M. 2014). Traveling increases opportunities for exposure, particularly in outbreak areas or healthcare settings, and also contributes to spreading the virus to new communities. Determining whether outbreaks are due to local circulation or imported cases is crucial for countries like Vietnam, which are progressing toward measles elimination. This distinction is an important indicator in evaluating whether elimination status has truly been achieved.

Finally, individuals living in areas with reported febrile rash cases had a 2.24-fold higher risk of

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measles compared to those in areas without such cases, with statistical significance. Although this risk was lower than the 3.96 reported by Hoang Thi Hai Hang (Hang, H. T. H. 2018), both studies confirm the strong association. This highlights the critical importance of community-based surveillance for suspected measles rash cases, with early detection and laboratory confirmation serving as key interventions to prevent widespread transmission.

Multivariate logistic regression analysis of factors associated with measles infection

The results of multivariate logistic regression analysis demonstrated that certain factors were strongly associated with measles risk, while others did not reach statistical significance. Specifically, sex (95% CI: 0.87–1.36; p = 0.77) and place of residence (95% CI: 0.67–1.09; p = 0.21) were not significantly associated with measles infection. This finding reflects the epidemiological characteristics of measles, in which any susceptible individual can be infected regardless of sex or area of residence.

In contrast, vaccination status showed a decisive protective effect. Unvaccinated individuals had the highest risk of infection; those who had received one dose showed a significantly reduced risk (95% CI: 1.20–3.34; p = 0.008), while those fully immunized with two doses achieved even stronger protection (95% CI: 1.34–10.68; p = 0.012). These results are consistent with previous epidemiological evidence, which estimated the protective efficacy of the first dose of measles vaccine at approximately 85% when administered at 9 months of age.

Other risk factors were also identified. Individuals with a history of direct contact with measles cases had a 1.68-fold higher risk of infection (95% CI: 1.21–2.33; p = 0.002), consistent with the respiratory transmission pathway of the virus. Recent travel within 21 days before rash onset increased the risk 1.39 times (95% CI: 1.05–1.84; p = 0.022), highlighting the role of mobility in facilitating disease spread, especially in endemic areas. Furthermore, living near reported outbreaks was associated with a 1.53-fold higher risk (95% CI: 1.09–2.16; p = 0.015), reflecting the cluster-like pattern of measles transmission and underscoring the need for active community-based surveillance.

Taken together, these findings indicate that the major risk factors for measles infection include vaccination status, history of contact with cases, recent travel, and residence in outbreak-affected areas. They underscore the critical importance of complete two-dose vaccination, along with robust epidemiological surveillance, contact management, and mobility control in the context of endemic transmission.

CONCLUSION

A cross-sectional descriptive study was conducted on 1,714 cases of suspected measles rash in Dak Lak Province from January 1, 2024 to June 30, 2025. A total of 1,273 cases were confirmed positive for measles-specific IgM antibodies, reported across various districts of the province.

Multivariable analysis identified the main risk factors associated with measles infection, including vaccination status, history of contact with measles cases, travel within 3 weeks prior to onset, and living near an outbreak area. Among these, receiving ≥2 doses of measles vaccine demonstrated the most significant protective effect.

These findings reaffirm the pivotal role of full vaccination coverage and highlight the necessity of epidemiological surveillance, contact management, and travel control to limit the spread of measles in the community.

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