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Turning the Tide on Measles: EOC-Led Response and School-Based Vaccination in Narathiwat Province's Outbreak, 2024–2025

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Abstract

This study aimed to describe the epidemiological characteristics of the 2024–2025 measles outbreak in Narathiwat Province, identify factors associated with severe illness, and evaluate the effectiveness of outbreak control measures. A suspected case was defined as fever with maculopapular rash plus cough, coryza, conjunctivitis, or Koplik's spots. Confirmed cases had laboratory evidence of infection, detected either by measles-specific immunoglobulin M antibodies using enzyme-linked immunosorbent assay or viral RNA via reverse transcription polymerase chain reaction. Epidemiologically linked cases met clinical criteria without laboratory confirmation but had documented exposure to a confirmed case. Between February 2024 and January 2025, 2,710 cases were reported: 47.0% suspected, 13.4% epidemiologically linked, and 39.6% confirmed. Most cases occurred in children aged 9 months to 4 years, and 9.3% of confirmed cases were severe. Risk factors included female gender (adjusted odds ratio (OR) 1.81, 95% confidence interval (CI) 1.18–2.79), age under 9 months (adjusted OR 7.84, 95% CI 1.77–34.70), and diarrhea (AOR 2.29, 95% CI 1.47–3.60). Following Emergency Operations Center activation, school-based surveillance, ring vaccination, vitamin A supplementation, and a phased vaccination campaign were implemented. School-based clusters declined from 19 to 1 within 42 days post-intervention. Ring vaccination coverage reached 65% and reduced secondary infections from 2.0% to 1.3% (p-value <0.01). The vitamin A uptake rate rose rapidly, reaching 100% by October 2024. The measles vaccine coverage increased from 47.9% to 65.0% among children aged under 12 years. These results highlight the outbreak burden in low-coverage areas and support integrated interventions.

Keywords: measles outbreak, measles vaccine, school-based vaccination, vitamin A, Emergency Operations Center, Narathiwat

Introduction

Measles is a highly contagious viral disease with high mortality. The disease caused an estimated 107,500 deaths globally in 2023, mainly among unvaccinated children under five years of age.[1] Thailand committed to measles elimination at the 63rd World Health Assembly in 2010 and implemented a strategic plan (2020–2024) under the National Expanded Program on Immunization (EPI), aiming for 95% coverage with the first dose of the measles, mumps, and rubella (MMR) vaccine (MMR1) at 9 months and the second dose of MMR (MMR2) at 18 months.[2] In Narathiwat Province, MMR1 coverage remained below 50%, contributing to an outbreak in 2024.[3] The province has historically faced challenges in vaccine coverage due to cultural and trust-related barriers. Persistent vaccine refusal, primarily due to parental concerns about halal content and vaccine side effects, remains a barrier.[4,5]

Measles transmission begins four days before rash onset and continues for a further four days. Symptoms include fever, cough, coryza, conjunctivitis, and rash.[6] Pneumonia is a common complication and the main cause of death.[7] Maternal measles infection increases the risk of adverse pregnancy outcomes, including fetal loss and neonatal death. Intravenous immunoglobulin (IVIG) is recommended for susceptible newborns.[8]

The MMR vaccine provides 93% protection after one dose and 97% after two doses.[9] Due to low routine MMR vaccine coverage, outbreak control measures such as ring vaccination are used to prevent further spread. However, as a live vaccine, it is contraindicated during pregnancy.[10] Vitamin A supplementation is also essential, particularly for malnourished children, to reduce disease severity.[11] In response to the outbreak, the Narathiwat Emergency Operations Center (EOC) was activated on 3 Sep 2024, to coordinate surveillance, isolation, and control measures. This study aims to describe the epidemiology of the outbreak, identify factors associated with severe illness, and evaluate the effectiveness of control measures.

Methods

To describe the magnitude and characteristics of measles cases between February 2024 and January 2025, the Narathiwat EOC applied a modified clinical case definition based on Thailand's national measles surveillance guideline.[12]

A clinical case was defined as a patient with fever and maculopapular rash plus at least one of the following: cough, coryza, conjunctivitis, or Koplik's spots.

Case classification comprised three groups. A suspected case was defined as an individual meeting the clinical criteria or clinically diagnosed by a physician. An epidemiologically linked case was defined as a suspected case without laboratory confirmation but with a documented link to a confirmed case through investigation. A confirmed case was a suspected case with laboratory confirmation, including a positive or equivocal immunoglobulin M (IgM) result or a positive reverse transcription polymerase chain reaction (RT-PCR) test.

High-risk contacts (HRCs) included individuals with close contact to suspected, epidemiologically linked, or confirmed measles cases, including household members, close contacts without masks, and healthcare workers without proper protective equipment.

Severe cases were those with complications such as pneumonia or respiratory distress, while non-severe cases had no complications.

Measles confirmation was done by IgM in blood (4–28 days after rash onset) and RT-PCR for viral RNA in throat or nasal swabs (5–14 days after rash onset), according to the Thailand national measles surveillance guideline.[12] Specimens were stored at −10 °C for up to 48 hours and transported within two hours to the Regional Medical Sciences Center 12, Songkhla.

Data on measles cases were collected through daily updates entered into the online patient registry by district health personnel. The collected data included demographics (age, gender, district of residence), clinical features (symptoms, pneumonia, hospitalization, mechanical ventilation, fatality), and vitamin A supplementation. Categorical variables were summarized using frequencies and percentages and continuous variables using medians with interquartile range (IQR).

A cross-sectional study was conducted to identify factors associated with severe cases among laboratory-confirmed measles patients as compared to non-severe cases. Variables included gender, age group, and occupational exposure risk (high: healthcare workers, students, teachers; intermediate: laborers, vendors, farmers; low: unemployed, dependents). Clinical factors included symptom-to-visit interval and symptoms. Univariable and multivariable logistic regression models were used to estimate an odds ratio (OR) with 95% confidence intervals (CI) for each variable in the model. Variables with p-value <0.2 were included in the multivariable model. Significance in the multivariable analysis was determined using the 95% CI. Analyses used R version 4.2.1.[13]

The effectiveness of outbreak response and control measures implemented by the Narathiwat EOC was assessed, focusing on school-based surveillance, vitamin A supplementation, ring vaccination, and the measles vaccination catch-up campaign.

School-based surveillance was implemented through symptom screening in kindergartens and primary school for early detection and isolation. Effectiveness was evaluated by comparing the number of schools reporting measles clusters, defined as two or more measles cases in the same class or with evidence of an epidemiological link in the same school within 14 days, before and after EOC activation.

Vitamin A supplementation was assessed by comparing the uptake rates, defined as the proportion of all cases receiving vitamin A, before and after EOC activation.

Ring vaccination targeted HRCs identified through contact tracing. The measles and rubella vaccine (MR) was administered to all HRCs, except that children aged under seven years received the MMR vaccine instead. Effectiveness was measured by the measles vaccine uptake rate within the MR or MMR vaccine among HRCs and the secondary infection rate, defined as the number of secondary cases divided by the total number of HRCs. A chi-square test compared proportions before and after EOC activation. Statistical significance was set at p-value <0.05.

The measles catch-up vaccination campaign was conducted in three phases to progressively increase cumulative vaccine coverage among approximately 63,519 unvaccinated children aged ≤12 years. Effectiveness was assessed using two indicators. First, phase-specific catch-up rates were calculated as the proportion of previously unvaccinated children receiving any measles vaccine in each phase of the campaign. Secondly, province-wide measles vaccination coverage was calculated by summing the number of children who received at least one dose of the measles vaccine before EOC activation (including routine MMR) and after EOC activation, including ring vaccination and the measles catch-up vaccination campaign (MMR or MR), then dividing by the total child population in Narathiwat Province.

Results

Outbreak Description in Narathiwat Province

The outbreak resulted in 2,710 measles cases: 1,273 suspected (47.0%), 364 epidemiologically linked (13.4%), and 1,073 confirmed (39.6%). The annual attack rate for measles in Narathiwat was 0.33%. The male-to-female ratio was 1.1:1. Children aged 9 months to 4 years accounted for the highest proportion (50.8%), followed by 5–9 years (22.7%), ≥10 years (17.4%), and <9 months (9.2%) (Table 1). Common symptoms included rash and fever (100%), cough (92.0%), coryza (83.2%), conjunctivitis (52.0%), diarrhea (50.4%), and Koplik's spots (7.5%). The median time from fever to rash was 3 days (IQR 1–4). Overall, 82.7% of cases were hospitalized, and 8.8% developed pneumonia. Pneumonia was most common in children aged 9 months–4 years (59.4%), followed by 5–9 years (18.4%) and <9 months (17.2%). Seven cases (0.3%) required mechanical ventilation. One neonatal death occurred despite IVIG administration (case fatality rate 0.04%). The mother had not received measles vaccination and was infected shortly before delivery.

Cases were distributed across multiple districts, highest in Rueso (420), Ra-ngae (371), and Bacho (360). Twenty school-based outbreaks were identified in kindergartens and primary schools. The epidemic curve peaked in September–October and declined by December. The EOC was activated on 3 Sep 2024, when weekly cases exceeded 162, and closed on 21 Jan 2025 (Figure 1). Laboratory testing confirmed the diagnoses. The IgM positive rate was 82.0% (998/1,217) and the RT-PCR positive rate was 83.2% (124/149).

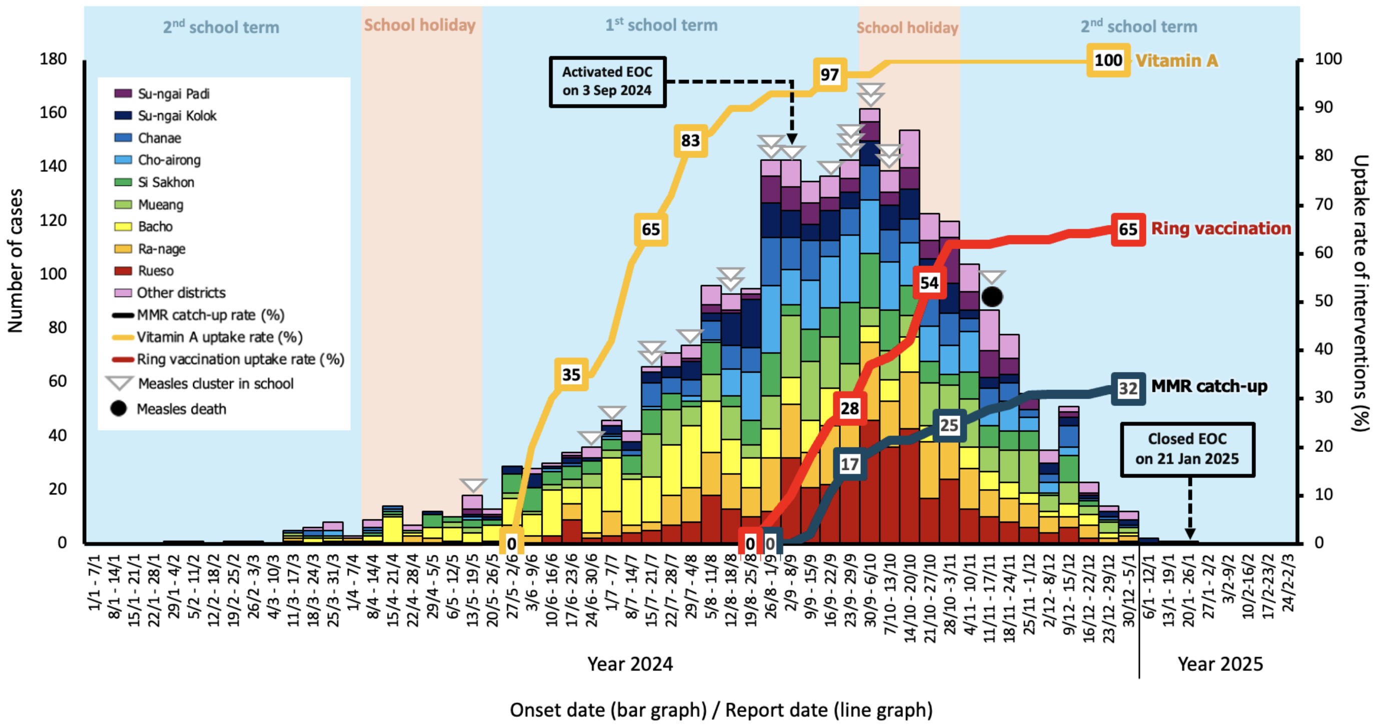

Figure 1. Weekly measles cases by district, school-based clusters, and uptake of key outbreak interventions in Narathiwat Province, Thailand, 2024–2025 (n=2,710)

Factors Associated with Measles Severity (Analytical Perspective)

Multivariable analysis showed female (adjusted OR 1.81; 95% CI 1.18–2.79), aged <9 months (adjusted OR 7.84; 95% CI 1.77–34.70), and having diarrhea (adjusted OR 2.29; 95% CI 1.47–3.60) were significantly associated with severe disease. Runny nose was not statistically significant (adjusted OR 1.25; 95% CI

0.64–2.44). Although the MMR vaccination status was not significant on multivariable analysis, individuals who were never vaccinated had a higher crude odds of severe disease (crude OR 1.82; 95% CI 0.97–3.40) compared to those with uncertain vaccination status (Table 1).

Table 1. Factors Associated with severe measles in Narathiwat Province, 2024–2025 (N=1,073)

Variables	Severe cases (n=100)	Non-severe cases (n=973)	Crude OR (95% CI)	Adjusted OR (95% CI)
Demographics				
Gender				
Female	58	456	1.56 (1.03–2.37)*	1.81 (1.18–2.79)
Male	42	517	Ref	
Age group				
<9 months	16	66	6.48 (2.10–20.23)*	7.84 (1.77–34.70)
9 months–4 years	55	497	2.96 (1.05–8.34)*	3.31 (0.83–13.25)
5–9 years	23	228	2.70 (0.91–8.00)*	2.93 (0.70–12.28)
10–14 years	2	75	0.71 (0.13–4.00)	0.84 (0.12–5.81)
≥15 years	4	107	Ref	
Risk factors				
Occupational exposure risk				
High	47	488	2.37 (0.73–7.83)*	1.10 (0.23–5.19)
Low	50	411	3.00 (0.91–9.88)*	4.28 (0.20–4.36)
Intermediate	3	74	Ref	
MMR vaccination status				
Never vaccinated	86	756	1.82 (0.97–3.40)*	1.01 (0.23–5.19)
MMR1 only	2	25	1.28 (0.27–6.05)	0.93 (0.20–4.36)
Uncertain	12	192	Ref	
Symptom onset to healthcare visit				
More than three days	75	676	1.32 (0.82–2.11)	
Within the first three days	25	297	Ref	
Associated signs and symptoms				
Cough				
Yes	97	922	1.79 (0.55–5.84)	
No	3	51	Ref	
Runny nose				
Yes	89	818	1.53 (0.81–2.94)*	1.25 (0.64–2.44)
No	11	155	Ref	
Conjunctivitis				
Yes	56	519	1.11 (0.74–1.69)	
No	44	454	Ref	
Diarrhea				
Yes	68	461	2.36 (1.52–3.66)*	2.29 (1.47–3.60)
No	32	512	Ref	

**Meeting selection criteria for multivariable analysis (p-value <0.2). OR: odds ratio. CI: confidence interval. MMR1: first dose of the measles, mumps, and rubella (MMR) vaccine.*

Outbreak Response and Control Measures

Following the activation of the Narathiwat EOC on 3 Sep 2024, targeted control measures were implemented to enhance surveillance, vaccination coverage, and outbreak containment.

School-based surveillance and control

School-based surveillance and isolation protocols were enhanced to enable early detection and containment of measles cases. Upon identification of a suspected case, teachers actively screened other symptomatic students through in-person checks or online surveys. Symptomatic students were hospitalized and isolated. Close contacts, including classmates and household members, were identified for ring vaccination. Students with fever or upper respiratory symptoms without rash were advised to remain at home for at least four days. Teachers conducted symptom screening in class for 42 days. This intervention reduced school-based transmission, with measles clusters decreasing from 19 to 1 school within 42 days post-intervention, covering two incubation periods (Figure 1).

Vitamin A supplementation

Vitamin A supplementation was provided to all cases regardless of laboratory confirmation, with priority given to children under five years of age, malnourished individuals, and those with signs of vitamin A deficiency. The dosage was based on age: 50,000 IU for infants under 6 months, 100,000 IU for those 6–12 months, and 200,000 IU for children aged 12 months or more. Two doses were given, one day apart. Daily monitoring ensured proper administration. The uptake rate increased rapidly from 0% to 90% within one month and reached 100% by October 2024 (Figure 1).

Ring vaccination

Ring vaccination was implemented for high-risk contacts of suspected measles cases in schools, workplaces, and households, regardless of vaccination history. The target was to administer the MMR or MR vaccine within 72 hours of exposure. District EOCs coordinated with local health teams to ensure timely vaccine deployment during case investigations. Coverage increased from 0% to 10% in September, 54% in October, and 65% by January 2025 (Figure 1). Secondary infection rates declined significantly from 2.0% (199/10,079 contacts) before EOC activation to 1.3% (262/19,798 exposures) after activation (χ^2 = 18.63, p-value <0.01).

Measles vaccination catch-up campaign

During the campaign, 20,454 children were vaccinated, representing 32.2% of the 63,519 targeted. Of these, 1,572 (7.7%) were preschool children, achieving 40.0% coverage in their group, and 18,882 (92.3%) were school-aged children (31.7% coverage). The campaign was conducted in three phases as shown in Figure 2.

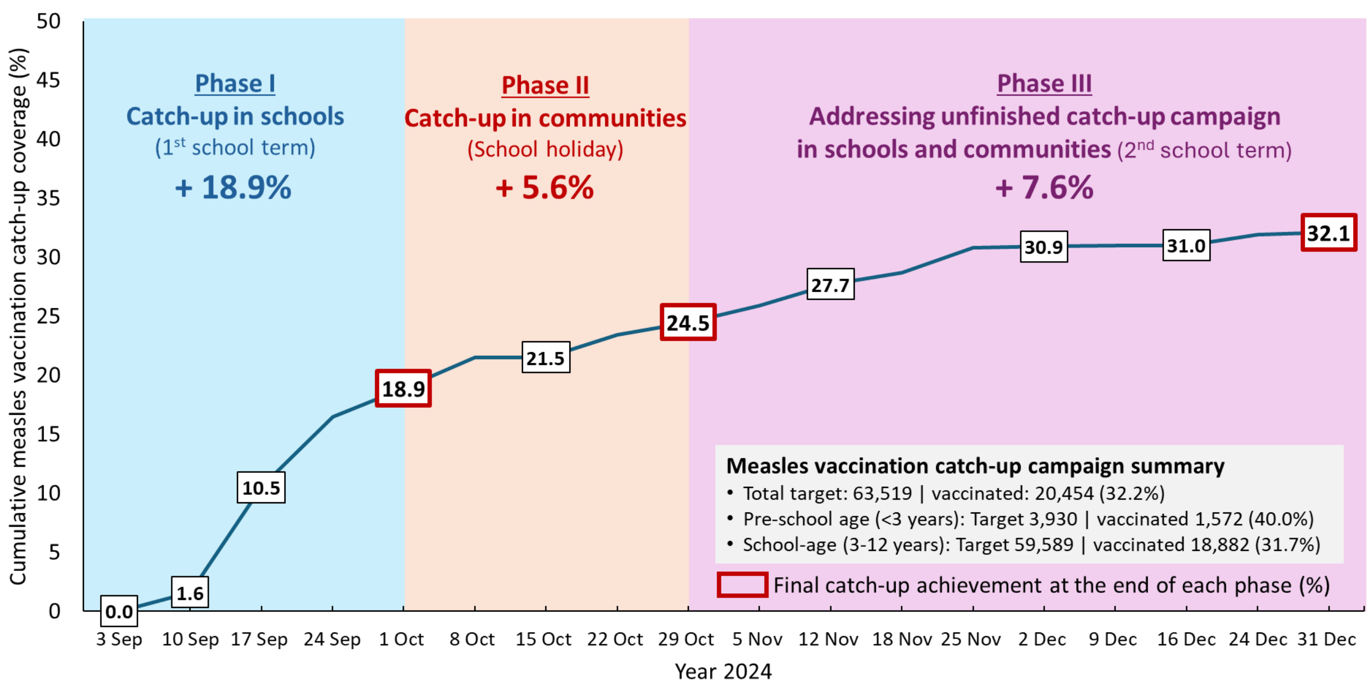

Figure 2. Phase-specific coverage during the measles vaccination catch-up campaign in the 2024 measles outbreak in Narathiwat Province

Phase I focused on school-based vaccination before the school break. A four-week plan began with communication via the LINE messaging application, which was already established in nearly all schools across Narathiwat. All pre-kindergarten and first-grade classes across the province had access to the application. Homeroom teachers played a key role by delivering all communication materials directly to parents. The materials were adapted from locally tested graphics developed under the Digital Results Improve Vaccine Equity and Demand (DRIVE Demand) project, piloted with caregivers in Rueso and Bacho districts. Messages, also translated into Malay, featured photo-based designs to build trust.[14] The Narathiwat EOC also released an official LINE message emphasizing measles severity and the importance of vaccination (Figure 3). Consent forms were then collected, and MMR or MR vaccines were administered based on the children's ages. Records were updated in health books and digital systems. By 1 October, coverage had increased by 18.9%.

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Figure 3. LINE-based communication materials, adapted from locally tested graphics developed under the DRIVE Demand project, promoting during the measles vaccination catch-up campaign in the 2024–2025 measles outbreak response in Narathiwat Province

Phase II extended to communities during school holidays, prioritizing districts according to case burden. High-risk areas, such as Sri Sakhon and Rueso districts, aimed for 10% weekly increases, moderate-risk areas for 7%, and low-risk districts maintained one session per week. Sri Sakhon and Tak Bai districts met their targets, while others required more engagement. By 29 October, coverage rose by 5.6%, reaching 24.5%.

Phase III closed the remaining gap, adding 7.6% coverage to reach 32.1% by 31 December.

The province-wide measles vaccination coverage (at least one dose) rose from 48% (n=58,525) to 65% (n=78,979) among children aged under 12 years (n=121,966).

Discussion

The 2024 measles outbreak in Narathiwat revealed important epidemiological patterns. Infants and young children were most affected, with severe outcomes, particularly in those aged under 9 months. Despite school-based surveillance, ring vaccination, vitamin A supplementation, and a vaccination catch-up campaign, vaccination gaps persisted. These findings highlight underlying vulnerabilities and inform strategies for immunological risks, intervention effectiveness, and strategies to strengthen outbreak preparedness.

Infants are initially protected by maternally derived anti-measles IgG antibodies; however, immunity wanes after 6–9 months, as seen in this outbreak, where the highest incidence occurred in children aged 9 months to 4 years.[15] However, the highest risk of severe disease was seen in infants aged under 9 months (adjusted OR 7.84, 95% CI 1.77–34.70). These findings align with prior studies reporting higher infection rates in children under five years and increased severity in those under one year of age.[16,17] Possible explanations include immune immaturity, smaller airways, and weaker cough reflexes.[18] Female gender may act as a proxy for other unmeasured factors, while diarrhea could reflect disease progression or contribute to severity through dehydration. These associations should be interpreted with caution.

The only fatality in this outbreak occurred in a newborn whose mother was infected shortly before delivery, highlighting the risk of insufficient transplacental antibody transfer and direct transmission from mother to child.[19] The infant did not survive despite IVIG, emphasizing the need for alternative treatments. MMR vaccination at 6 months during outbreaks may offer short-term protection, but a second dose after 12 months remains necessary.[15,20] Vaccinating women of reproductive age before pregnancy ensures maternal immunity and antibody transfer to infants. Postpartum vaccination of susceptible women is also recommended. However, infants born to mothers with vaccine-derived immunity tend to have lower antibody levels than those with natural infection.[8,21] For unvaccinated pregnant women exposed to measles, serologic testing and IVIG therapy within six days are advised.[8] However, given its high cost (30,000–40,000 THB per case),[22,23] the cost-effectiveness of IVIG therapy must be considered in outbreak preparedness policies.

Vitamin A deficiency increases measles severity and mortality, particularly among children under the age of five years.[11,24–26] In Narathiwat, the prevalence of vitamin A deficiency was 25.6% in 2019, exceeding the WHO threshold of 20%.[27,28] During the 2018–2019 outbreak, the case fatality rate was 0.92%, higher than the national average of 0.56%.[27,29,30] In response to the 2024 outbreak, vitamin A supplementation was provided to all suspected cases, prioritizing malnourished and vitamin A-deficient children.[31] The uptake rate reached 100% by October 2024. This contributed to a reduced mortality compared to the 2018 outbreak. However, at least two doses are needed to significantly reduce measles mortality.[32] While vitamin A is critical in case management, vaccination remains the most effective preventive strategy.

School-based catch-up vaccination is effective during measles outbreaks, especially in high-density classrooms. A four-week campaign in Narathiwat increased the coverage by 18.9%, with teachers playing a key role in communication and parental engagement, reducing school-based outbreaks within 35 days. These findings align with studies from Germany showing that vaccination within 6–14 days can prevent large outbreaks.[33] However, evidence suggests that school-entry vaccination verification remains the most effective preventive strategy, as reactive campaigns are costly and have limited benefits.[34,35] Teachers can contribute to vaccine acceptance by addressing hesitancy and delivering consistent messages.[36] Nonetheless, lack of knowledge among teachers regarding vaccine types, side effects, and preventable diseases limits their effectiveness.[37] Capacity-building for school nurses, parents, and teachers is essential for the long-term success of school-based vaccination programs.[38]

Limitations

Clinical information was collected only during the initial hospital visit or first contact with field investigators without any follow-up on symptom progression or later complications such as pneumonia or otitis media. The EOC online report lacked data on height, weight, and signs of vitamin A deficiency, limiting the assessment of baseline nutritional status and its association with severe illness. Finally, this was an observational study; therefore, causal inferences between interventions and outcomes cannot be established.

Recommendations

Prioritize Early MMR Vaccination

According to the national EPI, MMR1 is recommended at 9 months and MMR2 at 18 months. Based on our findings, we recommend administering an early first dose before 9 months for high-risk infants to ensure timely protection against measles.

Address Vaccine Hesitancy Through Trusted Community Engagement

Strengthen outreach efforts by involving respected local leaders, religious authorities, and healthcare professionals to promote vaccine acceptance, particularly in populations concerned about halal compliance and other cultural considerations.

Enhance School-based Surveillance and Vaccination

Empower teachers and school administrators as frontline advocates for immunization. Their active role in symptom screening, parent engagement, and health education has proven effective in reducing school-based outbreaks and improving vaccination coverage.

Maintain Vitamin A Supplementation during Outbreaks

Continue supplementation, especially in provinces with high deficiency rates, to mitigate complications and reduce mortality associated with measles.

Long-term Strategy

Implement catch-up vaccination campaigns as early as possible and develop communication tools to address parents' concerns and vaccine hesitancy. Focus on school-based vaccination, with teachers promoting immunization.

Conclusion

This study described the measles outbreak in Narathiwat Province from 2024 to 2025, identified factors associated with severe disease, and assessed the effectiveness of key control measures. Most cases occurred in children aged 9 months to 4 years, with infants under 9 months most affected by severe illness. Being female and having diarrhea were significant risk factors of severe illness, leading to longer hospital stays, increased need for medical resources, and higher mortality risk. The response, coordinated by the Emergency Operations Center (EOC), helped reduce transmission through early detection, ring vaccination, and vitamin A supplementation. The measles vaccination catch-up campaign increased coverage from 47.9 to 65.0%, highlighting the value of school and community-based strategies. Ongoing challenges such as vaccine hesitancy and operational gaps underscore the need for sustained, community-driven efforts to improve immunization in low-coverage areas.

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Author Contributions

Farooq Phiriyasart: Conceptualization, methodology, formal analysis, writing—original draft, writing—review & editing, supervision, project administration. **Ahamud Seerako:** Investigation, resources. **Tharathip Suksridaeng:** Resources, investigation. **Rusmanira Khwankerd:** Data curation, writing—review & editing. **Sasikarn Nihok:** Data curation, visualization. **Nungrutai Ninlakan:** Resources, data validation. **Peerawan Cheewaiya:** Investigation, writing—review & editing. **Noreeda Waeyusoh:** Resources, data support. **Ekawit Jindapet:** Supervision, writing—review & editing. **Adul Binyusoh:** Supervision, resources, writing—review & editing.

Ethical Approval

Ethical clearance was waived as this investigation was conducted under Narathiwat EOC outbreak management. Data collection was part of the investigation, with participants informed of the study objectives and benefits beforehand. Responses were recorded on forms without audio, ensuring anonymity by excluding full names and addresses. All documents are securely stored and accessible only to the principal investigator.

Informed Consent

Not applicable. This study used fully de-identified secondary data obtained from routine outbreak surveillance and reporting systems. No identifiable personal information was collected or used, and the data cannot be linked back to individual participants.

Data Availability

The data that support the findings of this study are available from the Narathiwat Provincial Public Health Office. Restrictions apply to the availability of these data, which were used under license for this study. Data are available from the corresponding author with permission from the Narathiwat Provincial Public Health Office.

Conflicts of Interest

The authors declare no conflicts of interest related to this work.

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Declaration of Generative AI and AI-assisted Technologies in the Writing Process

During the preparation of this work, the authors used ChatGPT (OpenAI) to improve clarity and correct grammatical errors. The content produced by this tool was reviewed and edited by the authors, who accept full responsibility for the final version.

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