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Lessons from a Measles Outbreak in a Military School: Rapid Response and Surveillance Gaps in Sattahip District, Chonburi Province, Thailand, 2025

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Abstract

Objectives: To confirm a measles outbreak in a military school in Sattahip District, Chonburi Province, Thailand, describe its epidemiologic characteristics, identify associated risk factors, and assess surveillance performance and response timeliness.

Methods: A descriptive and analytical field investigation was conducted among 374 cadets and staff from 30 Jun to 31 Aug 2025. Data were collected through case interviews, environmental assessments, record reviews, and laboratory testing. A retrospective cohort study was performed to identify risk factors. Hospital reporting performance was evaluated, and outbreak response timeliness was assessed using the WHO 7-1-7 detect–notify–respond framework.

Results: Thirty-two measles cases were identified (attack rate 8.6%), all among male cadets. Two waves of transmission occurred, first among second-year cadets and later among first-year cadets. Laboratory testing confirmed measles virus genotype D8 (DSID 9587), genetically related to strains previously detected in the district. Sharing a bathroom with a symptomatic individual (adjusted odds ratio (AOR) 3.12; 95% confidence interval (CI) 1.17–8.33) and close contact with a measles case (AOR 2.31; 95% CI 1.02–5.22) were risk factors, while leaving the school premises was protective (AOR 0.34; 95% CI 0.15–0.74). Outbreak response immunization achieved 100% coverage among cadets and staff and likely interrupted transmission within two incubation periods. Facility-based surveillance evaluation showed low reporting sensitivity (1.04%), indicating underreporting of clinically compatible cases. Although the overall response met the 7-1-7 timeliness targets, delays in symptom reporting and operational constraints were observed.

Public Health Recommendations: Strengthening measles surveillance sensitivity, improving early case reporting, and ensuring rapid outbreak response immunization are essential to prevent transmission in closed institutional settings.

Keywords: measles, outbreak investigation, military school, surveillance, Thailand

Introduction

Measles is one of the most contagious infectious diseases and is caused by a single-serotype measles virus with humans as the only reservoir.[1,2] Transmission occurs primarily through airborne respiratory particles, and the virus can remain viable in the air or on surfaces for up to two hours after an infectious person leaves the area.[1,3] The incubation period ranges from 7–21 days (typically 10–14 days), and infected individuals are contagious from four days before rash onset until four days afterward.[1,4]

Despite the availability of a safe and effective vaccine, measles remains a significant global public health concern.[2] In 2022, an estimated 9 million measles cases and 128,000 deaths were reported worldwide, primarily among children under five years of age.[1] The World Health Organization (WHO) Immunization Agenda 2030 and the Measles and Rubella Strategic Framework 2021–2030 aim to achieve and sustain measles elimination by 2030 through maintaining ≥95% coverage with two doses of measles-containing vaccine (MCV) and strengthening surveillance systems.[5]

WHO recommends the non-measles, non-rubella discard rate as a key indicator of measles surveillance sensitivity, with a target of at least two discarded suspected cases per 100,000 population annually.[6] This indicator reflects the ability of the surveillance system to detect and investigate febrile rash illnesses and ensure that measles transmission is not missed.

Thailand's measles elimination goal aligns with the WHO strategy to achieve and sustain measles elimination by 2030.[5] The national immunization schedule includes two doses of MCV administered at 9 months (MCV1) and 6–7 years (MCV2). National MCV2 coverage increased from 32.6% in 2013 to above 80% after 2016, reaching 86.5% in 2024 and 90.5% in 2025. However, only 16 of 77 provinces (20.8%) achieved the ≥95% coverage target in 2024, leaving pockets of susceptible individuals.[7]

Surveillance performance also varies across subnational areas. Although the national non-measles, non-rubella discard rate improved from 0.28 to 3.48 per 100,000 population between 2022 and 2024, the proportion of provinces achieving the WHO target remained limited.[6,7]

In Chonburi Province in eastern Thailand, surveillance data from 2022–2024 showed mainly sporadic cases without sustained transmission. However, on 23 Jun 2025, a measles outbreak was reported among cadets at a military school in Sattahip District. The index case developed fever on 20 Jun 2025, and additional febrile rash cases were identified between 26 and 29 June. Laboratory confirmation of measles on 30 Jun 2025 prompted a field investigation by local health authorities.

This investigation aimed to confirm the outbreak, describe its epidemiological characteristics, identify risk factors associated with measles infection among cadets, assess surveillance performance at the hospital level, and evaluate outbreak response measures, including outbreak response immunization.

Methods

This outbreak investigation was conducted at a military school located within a large peri-urban coastal military base in Sattahip District, Chonburi Province, Thailand. The school housed 331 cadets in dormitory-style accommodation with shared bathrooms and centralized dining halls. The investigation was conducted from 30 Jun to 31 Aug 2025 and examined measles events at the school beginning on 26 Jun 2025.

The study population included 374 individuals: all 331 cadets and 43 school staff members. Administrative personnel (e.g., visiting instructors and kitchen staff) were not included in active case finding because of logistical constraints.

A suspected case was defined as any study participant presenting with fever (temperature ≥38 °C) and maculopapular rash, or clinically suspected measles diagnosed by a physician, between 1 May and 15 Aug 2025. A laboratory-confirmed case was a suspected case with measles-specific IgM detected by ELISA or measles RNA detected by reverse transcription polymerase chain reaction (RT-PCR). An epidemiologically linked case was a suspected case without laboratory confirmation but had an epidemiological link to a laboratory-confirmed case within 7–21 days.

Active case finding was conducted through dormitory and classroom visits, face-to-face interviews, review of outpatient and inpatient hospital records, and contact tracing. A line list of cases was maintained and updated daily throughout the investigation.

The investigation included several components. First, a descriptive study characterized the outbreak by person, place, and time. Second, an environmental assessment was conducted on dormitories, classrooms, and common areas by focusing on crowdedness, ventilation and hygiene. Third, laboratory investigations using RT-PCR and measles-specific IgM ELISA were performed at the National Institute of Health and the

Thai Red Cross Emerging Infectious Diseases Clinical Center (TRC-EIDCC). Nasopharyngeal swabs for RT-PCR were collected within 0–3 days after rash onset. Measles cases with the identified genotype from public hospitals in Sattahip District were also reviewed to assess possible epidemiological links.

Fourth, a hospital-level surveillance rapid assessment was conducted at Somdech Phra Nangchao Sirikit Hospital by focusing on reporting sensitivity. Cases reported to the national measles elimination (ME) system were compared with hospital admissions meeting the fever—rash case definition using the International Classification of Diseases, 10th Revision (ICD-10) codes B05, B05.0–B05.4, and B05.8–B05.9.

Finally, a retrospective cohort study was performed to identify risk factors for measles infection among study participants.

Demographic information, clinical symptoms, and vaccination history were collected using case investigation forms and a supplementary online survey. Environmental observations followed WHO-recommended assessment checklists, and laboratory results were obtained from the TRC-EIDCC.[8] Contacts were monitored for 21 days after their last exposure; in this outbreak, monitoring was extended to 42 days (two incubation periods) as an enhanced surveillance measure in accordance with WHO outbreak control guidance.[8,9] Descriptive statistics were used to calculate attack rates and construct epidemic curves.

Univariable analysis was performed to estimate risk ratio (RR) with 95% confidence intervals (CI). Multivariable logistic regression was used to estimate adjusted odds ratio (AOR) and 95% CI for variables with p-values <0.05 in univariable analysis. Risk factors examined included demographic characteristics, sharing personal items, and close contact with confirmed cases, defined as sharing the same dormitory, classroom, or indoor airspace during the infectious period.

For the surveillance assessment, an assumed sensitivity of 34.1% from a recent evaluation of the national ME surveillance system conducted in Thailand was used as a reference.[10] Records with alternative confirmed diagnoses explaining febrile rash illness were excluded. A total of 186 hospital records meeting the fever–rash case definition was reviewed. Weighted analysis was applied to estimate surveillance sensitivity based on the probability of case capture within each ICD-10 stratum.

Outbreak response timeliness was evaluated using the WHO 7-1-7 framework (detected within seven days, notified within one day, and responded within seven days).[11] All analyses were performed using R version 4.5.1.

Results

Outbreak Description and Clinical Characteristics

During 23 Jun–14 Jul 2025, the school comprised 163 first-year cadets, 168 second-year cadets, and 43 staff members. It was an all-male institution with no female cadets or staff during the study period.

A total of 32 measles cases were identified, all among cadets. The overall attack rate among study participants was 8.6% (32/374), corresponding to 9.7% (32/331) among cadets. The attack rate was higher among second-year cadets (12.5%, 21/168) than among first-year cadets (6.7%, 11/163), and no cases were identified among staff. Among the 341 survey respondents, the attack rate was 9.4%.

Of the 32 cases, 15 were laboratory-confirmed and 17 were epidemiologically linked. The median age was 19 years (range 18–23 years), and no deaths or hospitalizations occurred (Table 1).

Table 1. Number of measles cases and attack rates in a military school, Sattahip District, Chonburi Province, June–July 2025.

Group	Number of cases (n)	Registered school population (based on school records)		Questionnaire respondents	
		Number (n)	Attack rate (%)	Number (n)	Attack rate (%)
First-year cadets	11	163	6.75	157	7.00
Second-year cadets	21	168	12.50	163	12.88
Instructors	0	43	0.00	21	0.00
Total	**32**	**374**	**8.56**	**341**	**9.38**

All cases presented with fever and maculopapular rash. Additional symptoms included cough (37.5%), rhinorrhea (18.8%), conjunctival injection (12.5%), and diarrhea (6.3%). Nine cases (28.1%) reported receiving at least one dose of MCV during childhood; however, the exact timing of vaccination could not be recalled.

The epidemic curve showed two waves of transmission. The first wave occurred among second-year cadets following the index case, who developed rash on 23 Jun 2025, with a rapid increase in cases during 24–28 June. The second wave occurred among first-year cadets between 6–18 Jul 2025 (Figure 1).

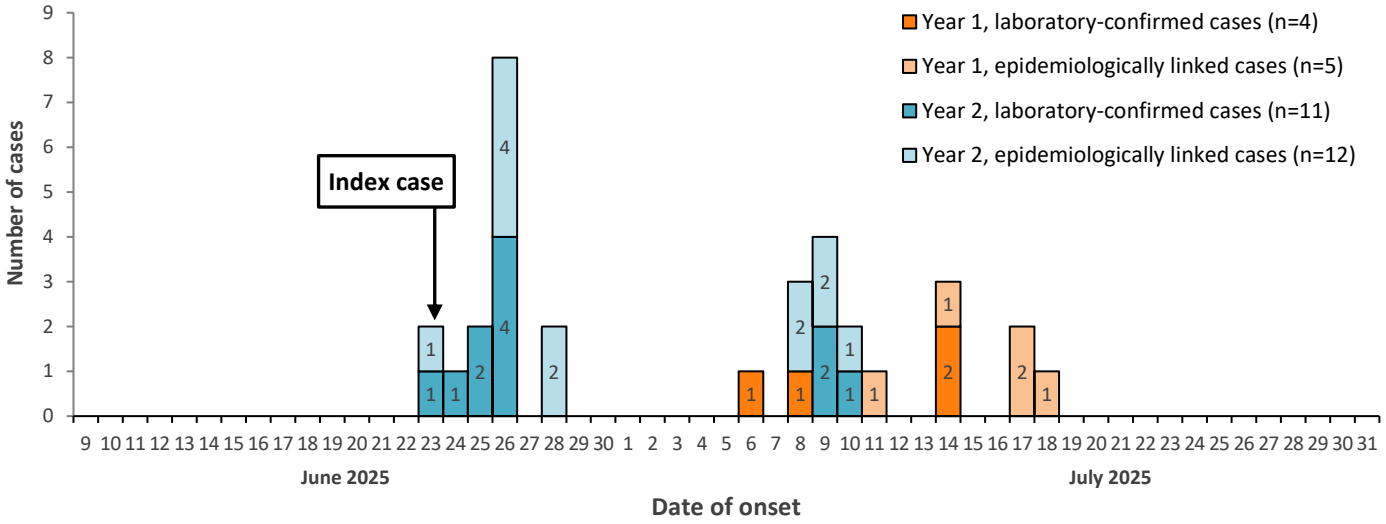


Figure 1. Epidemic curve of measles cases by cadet year and date of rash onset, military school, Sattahip District, Chonburi Province, June–July 2025 (n=32).

Environmental assessment showed that first- and second-year cadets lived in separate dormitories and used different dining halls but participated in shared recreational activities after school hours. Dormitories and classrooms were crowded, with an estimated living space of 3.3 m^2 per person—slightly below the Sphere minimum standard of 3.5 m^2 per person for communal shelters.[12] Bathrooms were small and congested. Cadets attended lectures and physical training from 8:00 AM to 4:00 PM on weekdays and were allowed to return home on weekends.

Five environmental swab samples from frequently touched surfaces (e.g., drinking glasses, bed frames, and bathroom doors) tested negative for measles RNA by RT-PCR at the TRC-EIDCC.

Among 32 suspected cases, 22 were tested for measles IgM and eight were positive (36.4%). Twelve nasopharyngeal swab samples were tested by RT-PCR, yielding eight positive results (66.7%). One case tested positive by both RT-PCR and IgM. All RT-PCR-positive samples were identified as measles virus genotype D8 (DSID 9587).

Risk Factor Analysis and Control Measures

Univariable analysis showed that sharing bathrooms with symptomatic individuals (RR 5.02, 95% CI 2.52–9.98), sharing drinking glasses (RR 5.00, 95% CI 2.12–11.8), and close contact with measles cases (RR 3.11, 95% CI 1.58–6.11) were significantly associated with infection. Leaving the school premises was associated with lower risk (RR 0.44, 95% CI 0.22–0.90) (Table 2).

Table 2. Univariable analysis of risk factors associated with measles infection among cadets, Sattahip District, Chonburi Province, June–July 2025.

Variable (risk factor)	RR	95% CI	*P*-value
Used a shared toilet with symptomatic persons	5.02	2.52–9.98	<0.001
Shared personal drinking glasses or utensils with others	5.00	2.12–11.79	<0.001
Close contact with a measles case	3.11	1.58–6.11	<0.001
Traveled outside the school compound	0.44	0.22–0.90	<0.01
Did not share meals during mealtimes	1.45	0.66–3.21	0.270
Washed hands regularly before meals	0.60	0.25–1.41	0.178
Wore a mask when visiting public places	0.65	0.30–1.41	0.207
Received at least one dose of the MCV in childhood	0.68	0.27–1.70	0.312

RR: risk ratio. CI: confidence interval.

Multivariable logistic regression identified three significant factors. Sharing bathrooms with symptomatic individuals (AOR 3.12, 95% CI 1.17–8.33) and close contact with measles cases (AOR 2.31, 95% CI 1.02–5.22) increased the risk of infection, while leaving the school premises within the past two months was protective (AOR 0.34, 95% CI 0.15–0.74). Sharing drinking glasses was no longer significant after adjustment (AOR 2.42, 95% CI 0.74–7.92) (Table 3).

Table 3. Multivariable logistic regression analysis of factors associated with measles infection among cadets, Sattahip District, Chonburi Province, June-July 2025.

Variable (risk factor)	AOR	95% CI	*P*-value
Used a shared toilet with symptomatic persons	3.12	1.17–8.33	0.017
Close contact with a measles case	2.31	1.02–5.22	0.042
Traveled outside the school compound	0.34	0.15–0.74	0.006
Shared personal drinking glasses or utensils with others	2.42	0.74–7.92	0.135

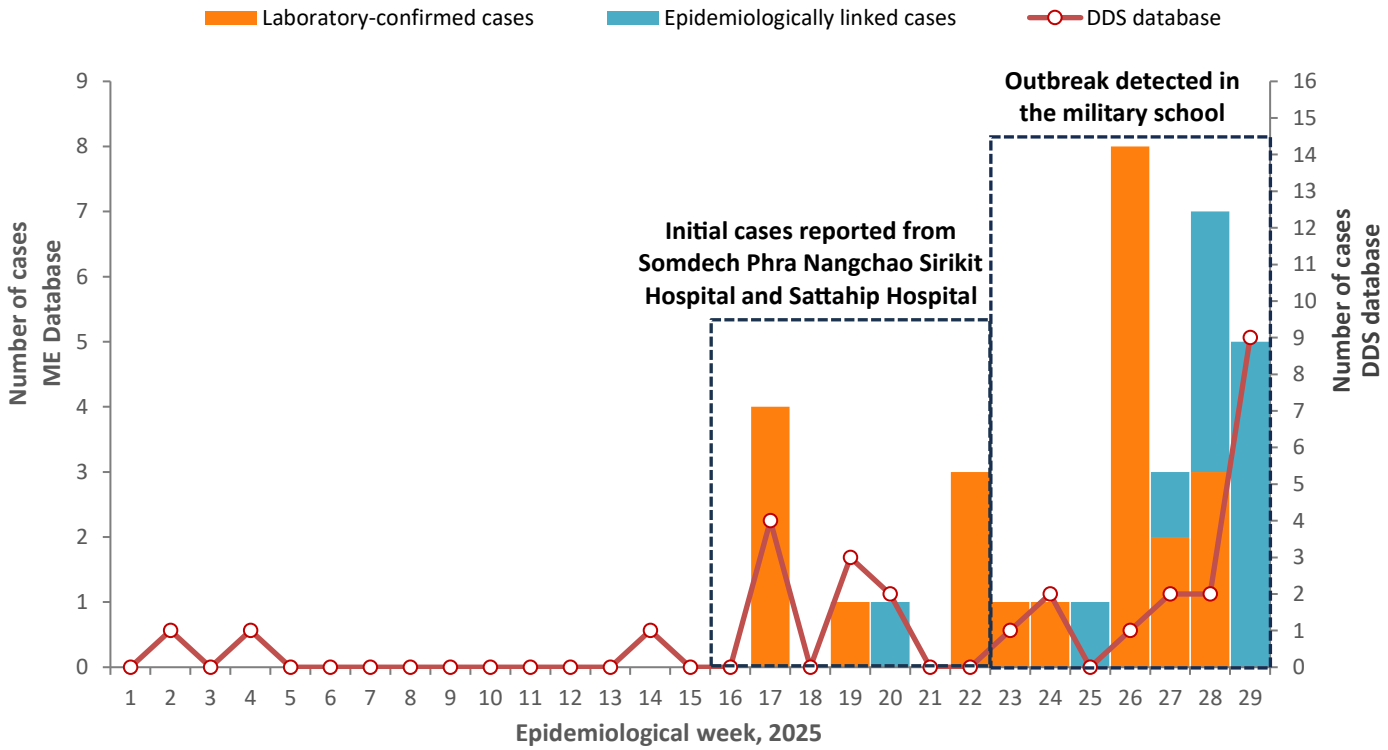
AOR: adjusted odds ratio. CI: confidence interval.

Control measures included case isolation, enhanced surveillance, risk communication, and outbreak response immunization regardless of vaccination history. Cases were isolated for at least four days after rash onset. Daily monitoring for febrile rash was conducted within the school and affiliated healthcare facilities.

Vaccination was conducted sequentially, beginning with second-year cadets, followed by first-year cadets and staff. As of 29 Aug 2025, corresponding to two incubation periods (42 days) after the last reported case, no new cases were identified and all cases had recovered.

Measles Surveillance, Index Case Investigation, and Outbreak Description in Sattahip District

Surveillance data showed sporadic measles cases in Sattahip District but increased reporting during epidemiological weeks 16–22 of 2025 (14 April–1 June 2025) (Figure 2).



Orange bars indicate laboratory-confirmed cases, blue bars epidemiologically linked cases from the measles elimination (ME) surveillance system, and the red line suspected cases reported through the Department of Disease Control surveillance (DDS) database.

Figure 2. Weekly distribution of febrile rash and suspected measles cases by laboratory confirmation and epidemiological linkage, Sattahip District, Chonburi Province, 2025 (n=32).

A facility-based surveillance evaluation at Somdech Phra Nangchao Sirikit Hospital demonstrated low reporting sensitivity (1.04%) in 2024, based on two reported measles cases among 186 hospital records meeting the fever–rash case definition.

The earliest case detected in the school was a second-year cadet who developed fever on 20 Jun 2025 and rash on 23 Jun 2025. He had remained within the military camp for the preceding three months and reported no travel history or known exposure to measles cases. Measles infection was confirmed by RT-PCR.

To assess possible community–school linkage, measles cases with genotype D8 (DSID 9587) identified in Sattahip District were reviewed. The earliest laboratory-confirmed case was a 47-year-old military officer who returned from southern Thailand and developed rash on 29 Apr 2025. Two additional community cases occurred before the school outbreak, including an eight-month-old infant (rash onset 12 May 2025) and a hospital vendor (rash onset 3 Jun 2025). However, no direct epidemiological link to the school could be established.

National molecular surveillance indicates that genotype D8 was the predominant measles genotype detected in Thailand during the 2024 resurgence and is commonly associated with international transmission.[7,13,14]

Actions Taken

Following laboratory confirmation of the measles outbreak, control measures were rapidly implemented. Symptomatic individuals were isolated until four days after rash onset, and active case finding was conducted among close contacts through daily screening for fever and rash.

Environmental control measures included daily cleaning and disinfection of classrooms, dormitories, and shared facilities using 0.1% sodium hypochlorite solution and alcohol-based disinfectants. Health education sessions were provided to cadets and staff, emphasizing respiratory hygiene, cough etiquette, mask use, and regular hand hygiene. N95 respirators were recommended for staff caring for suspected or confirmed cases.

A school-wide outbreak response immunization using the measles–rubella vaccine was implemented for all cadets and staff. The first vaccination round targeted second-year cadets on 9 Jul 2025, followed by rounds on 22 and 28 Jul 2025 to cover remaining cadets and absent individuals. In total, 344 cadets and staff received the vaccine.

Based on the WHO 7-1-7 framework, outbreak detection, notification, and response met the recommended timeliness targets. Delayed symptom reporting by cadets and absence of routine health screening contributed to delayed case detection, though coordination between military and public health teams enabled rapid investigation and implementation of control measures.

Discussion

This investigation confirmed a measles outbreak in a military boarding school, affecting 32 cadets across two epidemic waves. The outbreak occurred in a crowded residential setting where close contact and shared facilities likely facilitated transmission. Second-year cadets were affected first, followed by first-year cadets, suggesting sequential spread between dormitory groups.

The environmental conditions of the school likely contributed to transmission. Dormitories and classrooms were crowded, with an estimated living space of 3.3 m^2 per person, slightly below the Sphere minimum standard of 3.5 m^2 per person recommended to reduce health risks associated with overcrowding.[12] Previous studies have shown that residential schools and dormitory settings facilitate measles transmission due to prolonged close contact and shared living spaces.[3,15,16]

Laboratory investigation showed lower-than-expected positivity rates for measles IgM ELISA (36.4%) and RT-PCR (66.7%). Most specimens were collected within three days after rash onset, when IgM antibodies may not yet be detectable and viral RNA levels can vary. Therefore, the relatively low detection rates likely reflected the timing of specimen collection rather than absence of infection, although suboptimal specimen quality cannot be completely excluded.[8,13]

Molecular analysis identified measles virus genotype D8 (DSID 9587) in both the school index case and community cases detected earlier in Sattahip District. The earliest identified case was a military officer who had recently returned from southern Thailand, followed by additional community cases before the school outbreak occurred. Although no direct epidemiological link between the officer and the school could be established, the temporal sequence and genotype similarity suggest community introduction followed by local transmission before spread within the school.

The affected cadets were aged 18–23 years, corresponding to birth cohorts with estimated vaccine-derived immunity of approximately 85–90% nationally.[7]

This level remains below the 95% threshold required for herd immunity, leaving a proportion of susceptible individuals. Serological studies from Chonburi Province have also demonstrated relatively low measles immunity in similar birth cohorts, suggesting that immunity gaps may persist in young adults despite prior vaccination.[17–19] In this context, once measles was introduced into a crowded residential environment, transmission could occur rapidly.

A facility-based surveillance evaluation showed a reporting sensitivity of only 1.04% in 2024 among clinically compatible febrile rash cases. This finding indicates that many suspected cases were not captured by the surveillance reporting system. Strengthening surveillance performance, including routine active case finding, timely specimen collection, and regular surveillance evaluations, will help support Thailand's measles elimination goals.

Although outbreak detection, notification, and response met the WHO 7-1-7 timeliness targets, several operational challenges were identified. Delayed symptom reporting by cadets and the absence of routine health screening contributed to delayed case detection. In addition, the crowded dormitory environment may have limited the feasibility of distancing measures. Despite these constraints, rapid coordination between military and public health teams facilitated prompt implementation of control measures, including outbreak response immunization, which likely contributed to rapid containment of the outbreak.

Measles-containing vaccines remain highly effective against all circulating genotypes, including D8.[21] Maintaining vaccination coverage of at least 95% and strengthening surveillance systems remain essential to prevent future outbreaks and sustain measles elimination efforts.

Limitations

First, individuals who were regularly present at the school but not residing on campus, such as visiting instructors and kitchen staff, were not included in the study, which may have introduced selection bias.

Second, environmental samples were collected several days after cluster recognition rather than immediately after case detection, potentially reducing the likelihood of virus detection

Third, although the outbreak notification and initial response met the WHO 7-1-7 benchmark, interviews and transmission chain reconstruction began several days after cluster recognition, which may have introduced memory bias in reporting symptom onset and exposure history. Fourth, vaccination history relied largely on participant self-reports, as written immunization records were incomplete or unavailable, leading to possible misclassification of immunity status.

Finally, delayed symptom reporting and the absence of routine health screening may have affected the timeliness of case detection within the surveillance system and potentially compromised the completeness of the estimated outbreak magnitude.

Public Health Recommendations

Based on the findings of this investigation, several measures should be considered to prevent similar outbreaks. Verification of measles vaccination history at school or military entry should be strengthened, particularly for cadets aged 17–24 years. Individuals without documented two-dose measles-containing vaccine (MCV) should receive catch-up vaccination to reduce immunity gaps in congregate settings.

Schools with residential facilities should improve environmental conditions, including ventilation in dormitories and classrooms and hygiene practices in shared spaces. Health education should emphasize early symptom recognition and prompt reporting of febrile rash illness.

Measles surveillance should be strengthened through routine fever–rash screening during outbreaks, timely reporting to the national surveillance system, and training of school health personnel on case detection and specimen collection. Early laboratory confirmation, particularly through RT-PCR during the first days after rash onset, should be prioritized, and rapid response protocols should enable timely outbreak response immunization when clusters are detected.

Conclusion

We confirmed a measles outbreak in a boarding school in Sattahip District, with an attack rate of 8.6%. The event may be associated with underlying immunity gaps, as well as limitations in the surveillance system. Key risk factors included sharing bathrooms, being a close contact, and continuous residence in the school. A school-wide outbreak response immunization, alongside case isolation and enhanced surveillance, successfully contained the outbreak. Strengthening vaccination coverage, improving surveillance sensitivity and reinforcing school-based control measures are essential to preventing future measles outbreaks and to support Thailand's measles elimination goals.

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Authors Contributions

Piyada Angsuwatcharakon: Conceptualization, methodology, investigation, data curation, formal analysis, visualization, writing—original draft, writing—review & editing, project administration. **Kwannet Meengoen:** Investigation, data curation, formal analysis, validation, visualization, writing—review & editing. **Supagarn Phivgategaew:** Investigation, resources, data curation, project administration, writing—review & editing. **Montriya Unteamsom:** Investigation, project administration, Writing – review & editing, writing—review & editing. **Supakorn Promjad:** Investigation, project administration, writing—review & editing. **Rapeepong Suphanchaimat:** Conceptualization, methodology, investigation, formal analysis, validation, visualization, supervision, writing—review & editing.

Ethical Approval

Ethical approval was not required because this investigation was conducted as part of the routine disease containment function of the Department of Disease Control.

Informed Consent

Informed consent was not required because this investigation was conducted as part of the routine disease containment function of the Department of Disease Control. All data were presented anonymously to protect the confidentiality of the participants.

Data Availability

The data that support the findings of this study are available from the corresponding author upon reasonable request.

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 the clarity, coherence, and grammar of the manuscript. The authors reviewed and edited all content produced by this tool and accepted full responsibility for the final version of the manuscript.

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