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An Investigation of Pertussis Outbreak in a Low Vaccination Coverage Area, Mae Lan District, Pattani Province, Thailand, September–December 2023

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Abstract

On 26 Oct 2023, a pertussis cluster was reported in Muang Tia Subdistrict. We investigated to identify the source, determine contributing factors, and estimate diphtheria-tetanus-pertussis (DTP) vaccine coverage. We reviewed medical records and performed active case findings in three villages. Suspected cases included close contacts with upper respiratory tract infection (URI) symptoms, residents with a week-long cough and a typical pertussis symptom, or those in URI clusters. Confirmed cases were individuals with positive *Bordetella Pertussis* result by polymerase chain reaction. Age-appropriate DTP coverage was estimated. Post-hoc analysis on sensitivity of national (two-week cough with a typical symptom) and modified (any cough duration with a typical symptom or close contact with a URI symptom) pertussis definition was conducted. We found eleven confirmed and four suspected cases (attack rate 0.6%; 15/2,394) with one hospitalized with pneumonia. Cases' age ranged from 11 months to 53 years old (median 5 years). The attack rate among children aged 0–1 year was 2.9%. Thirty-six percent of confirmed cases had a cough lasting at least two weeks. The national definition had a sensitivity of 9.1% (95% CI 0.2%–41.3%), while the modified definition's sensitivity was 81.8% (95% CI 48.2%–97.7%). DTP coverage in children aged 0–1 year was 25.0% (95% CI: 10.4%–39.6%). Pertussis positivity among household and community contacts was 40.0% and 50.0%, respectively. This pertussis outbreak was driven by low vaccine coverage and community transmission. Enhancing vaccine coverage to 90% and using modified definitions are recommended for outbreak control in low-vaccination areas.

Keywords: pertussis, outbreak, community, diphtheria-tetanus-pertussis vaccine, Thailand

Introduction

Pertussis, caused by *Bordetella pertussis*, is a highly contagious respiratory disease with a 7–10-day incubation period. Symptoms progress through catarrhal, paroxysmal, and convalescence stages. It spreads via droplets and is contagious from the catarrhal stage to the third week of paroxysms or until five days after antibiotic initiation.[1,3] One-third of infants require hospitalization.[1,2] Diagnosis involves clinical and laboratory tests such as polymerase chain reaction (PCR). Macrolides and co-trimoxazole are recommended for treatment and postexposure prophylaxis.[4–7]

Although highly contagious, pertussis is vaccine-preventable. Thailand's Expanded Program on Immunization (EPI) schedules five doses of diphtheria, tetanus, and whole-cell pertussis (DTwP) vaccines at 2, 4, 6, 18 months, and 4–6 years of age.[8,9] The diphtheria, tetanus, and acellular pertussis (DTaP) vaccine can be used instead of DTwP.[8] The vaccine effectiveness against pertussis is 94% (95% confidence interval (CI) 88–97%) for DTwP and 84% (95% CI 81–87%) for DTaP.[10] The tetanus, diphtheria, acellular pertussis (Tdap) vaccine is recommended every 10 years for individuals over age seven.[8,11] Studies show that Tdap protects 73% of adolescents in the first year after

vaccination.[12] In pregnant women, Tdap at 27–36 weeks lowers pertussis risk in infants under 2 months by 78%.[12]

The World Health Organization (WHO) recommends at least 90% of a third dose of diphtheria-tetanus-pertussis (DTP3) vaccine coverage.[13] In 2023, Thailand's DTP3 coverage was 88.3%.[15] However, the Deep South—comprising the provinces of Pattani, Narathiwat, Yala, and parts of Songkhla—had lower coverage due to longstanding conflict and social challenges, including declining immunization.[14] Among the provinces in the Deep South, Pattani Province reported the lowest (53.3%).[15]

On 26 Oct 2023, a cluster of six confirmed pertussis cases in Village 5, Muang Tia Subdistrict, Mae Lan District, Pattani Province was notified. The index case was a DTP-unvaccinated 11-month-old Thai boy. We investigated from 31 Oct–1 Nov 2023 to confirm the outbreak and diagnoses, identify the source and contributing factors, assess DTP vaccine coverage, determine the sensitivity and specificity of the pertussis case definitions, and provide recommendations and control measures.

Methods

Descriptive Study

We reviewed medical records from Mae Lan Hospital, Pattani Hospital and Hat Yai Hospital, where six cases were diagnosed. We reviewed investigation reports from the Pattani Public Health Office and performed laboratory studies to confirm the diagnosis. We also reviewed the pertussis situation in Pattani Province between 1 Jan and 26 Oct 2023 from Thailand's indicator-based surveillance system (R506), and event-based surveillance, to verify the outbreak.

Active case finding was conducted in Villages 4–6. Community health volunteers and village leaders were explained the field visit's objectives and trained to perform active case finding. Each volunteer performed a walkthrough survey by visiting every household in their area to identify suspected cases, children, and pregnant women. They would then notify the investigation team to conduct face-to-face interviews using semi-structured questionnaires with all suspected cases and all members of households where children aged 0–1 year or pregnant women at 20-36 weeks of gestation lived.

Operational definition

A suspected case was a close contact of a confirmed case with at least one upper respiratory-tract-infection (URI) symptom (cough, rhinorrhea, sore throat) or residents in Villages 4–6 who had a week-long cough with a typical pertussis symptom (paroxysmal coughing, inspiratory whooping, post-tussis vomiting, apnea, cyanosis), or residents in Villages 4–6 who were in URI clusters between 22 Sep and 16 Dec 2023. Confirmed cases were suspected cases with positive *Bordetella pertussis* results by PCR technique. Suspected cases with negative PCR results were excluded.

A close contact was a person who had direct exposure to a confirmed case's respiratory secretion or face-to-face contact within one meter for over five minutes, categorized as low or high risk based on the proper use of personal protective equipment.[16] PCR-positive close contacts without symptoms were classified as asymptomatic infections.

Laboratory investigation

Nasopharyngeal swabs from suspected cases and high-risk contacts were collected by trained healthcare officers and transported at 2–8 °C to Bamrasnaradura Infectious Diseases Institute for *Bordetella pertussis* testing using the PCR technique.

Environmental survey

A walkthrough survey of index houses, communities, schools, and hospitals was conducted using direct observation and interviews with household members, residents, teachers, and healthcare officers. The survey focused on locations and behavioral risk factors such as mask-wearing, hand washing, and sharing personal items.

Vaccine Coverage Study

As DTP2 coverage data were unavailable, DTP vaccination coverage for doses 1, 3, 4, and 5 in 2023 was reviewed at the level of districts in Pattani Province, subdistricts in Mae Lan District, and villages in Muang Tia Subdistrict using Thailand's Health Data Center dashboard. We performed the DTP vaccination survey in suspected cases and children aged 0–1 year in Villages 4–6 during the active case finding. We interviewed parents about their child's vaccination and reviewed the vaccination record book. Age-appropriate DTP vaccine coverage was assessed as complete, incomplete, or unvaccinated based on age and number of doses received compared to EPI schedules.

Post-hoc Analysis of Sensitivity and Specificity of National and Modified Pertussis Definitions

To identify a pertussis definition suitable for outbreak periods, we modified the operational pertussis definition and analyzed the sensitivity and specificity of both national and modified definitions. The national definition requires a two-week cough

with a typical symptom, while the modified definition includes any cough duration with a typical symptom or close contact with a URI symptom.[17] The study included individuals during this outbreak who underwent PCR testing for pertussis. Sensitivity was the percentage of PCR-positive cases meeting the definition, while specificity was the percentage of PCR-negative cases not meeting the definition. Confidence intervals were calculated using the Clopper-Pearson Exact Method. The sample size was calculated using the finite population proportion formula with 95% confidence, 5% margin of error, and the WHO clinical criteria sensitivity of 95.2%.[18] Given a population of 2,394 in Villages 4–6, the required sample size was 68.

Ethics

Ethics approval was not required as it was part of an outbreak response by the Department of Disease Control, Ministry of Public Health.

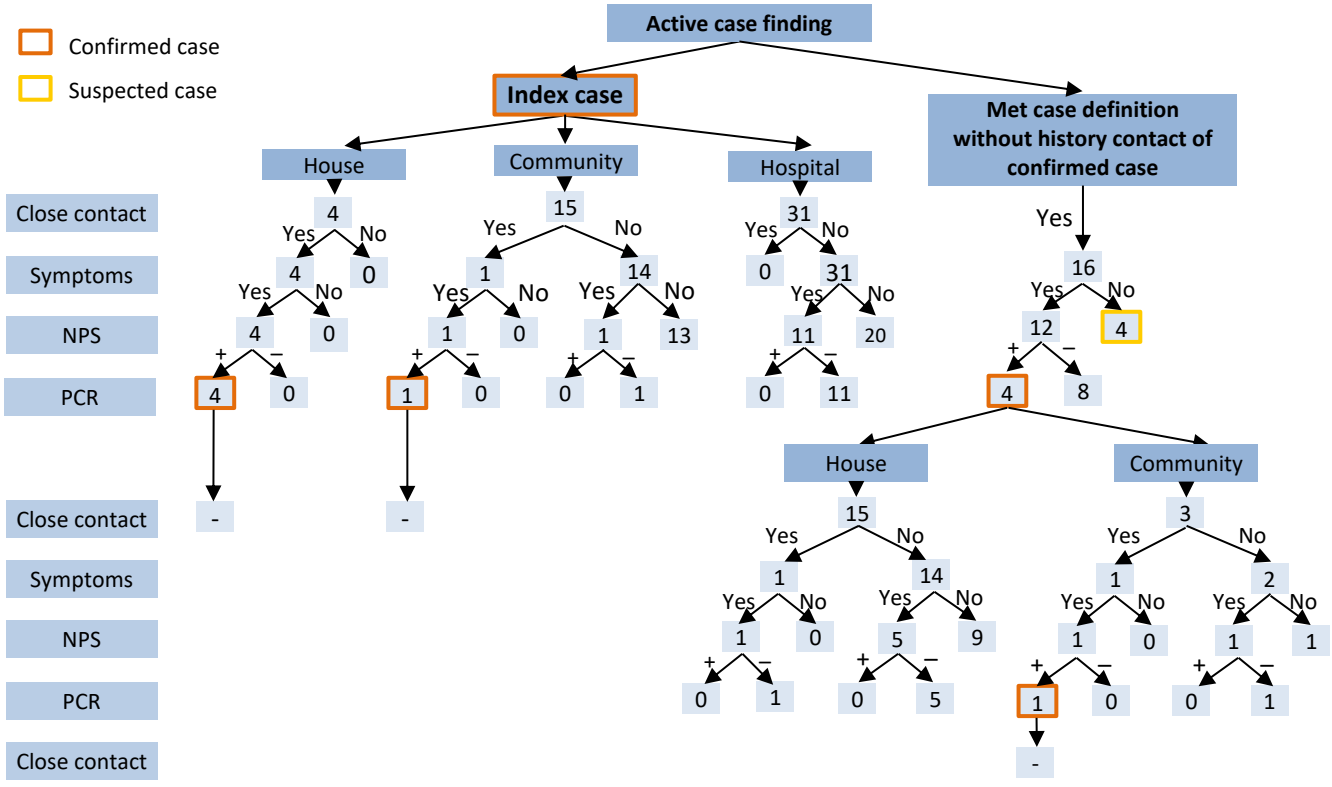
Results

Between 1 Jan and 26 Oct 2023, no pertussis cases were reported in Muang Tia Subdistrict, Mae Lan District, Pattani Province, from either the R506 or event-based surveillance systems. Muang Tia Subdistrict consists of six villages. The population is 90% Muslim. The adult-to-child-to-elderly ratio is 5.2:2.1:1.0. This investigation focused on Villages 4–6, with 594 households and 2,394 populations.

Outbreak Description and Magnitude

We traced close contacts of the index case and searched for suspected cases in the community (Figure 1). The index case had 50 close contacts. Of these, 17 close contacts underwent nasopharyngeal swabs, with five testing positive, confirming the previously notified cases. Additionally, we identified 16 symptomatic individuals who met the case definition without contact with confirmed cases; four met suspected cases definition, and 12 were tested with four positive. Among their close contacts, eight were tested and one was positive. In summary, we found an additional nine cases apart from the six notified cases. Among 19 household contacts, four of ten were positive (positivity rate 40%); among 18 community contacts, two of four tested positive (positivity rate 50%). No asymptomatic PCR-positive cases were found.

In total, we identified 15 cases (4 suspected and 11 confirmed cases). Five cases were from Village 4 and ten from Village 5. Age ranged between 11 months and 53 years (median 5 years, interquartile range 2–13 years). The male-to-female ratio was 1:1. There were eight students, four preschoolers, two vendors, and one army volunteer. Among 12 cases with DTP vaccination data (excluding three adults with unknown vaccination status), five were unvaccinated, four had 1–2 doses, and three had at least 3 doses. Considering age-appropriate DTP vaccination, five were unvaccinated, seven were incomplete, and none were completely vaccinated.



NPS: nasopharyngeal swabs. PCR: polymerase chain reaction.

Figure 1. Diagram of active case finding in Villages 4-6, Muang Tia Subdistrict, Mae Lan District, Pattani Province, September–December 2023

Among 11 confirmed cases, cough symptoms lasted 2–19 days (median 7 days, interquartile range 5–14 days), with four lasting 2 weeks. Typical symptoms included paroxysmal cough (n=4), post-tussive vomiting (n=2), whooping cough (n=1), and cyanosis (n=1) with no apnea. One case was hospitalized, and no deaths occurred. The hospitalized case was the 11-month-old boy index case from Village 5. He had no underlying diseases and never received the DTP vaccine. On 13 Oct 2023, he developed inspiratory whooping and dyspnea and went to the hospital the next day. He was diagnosed with acute bronchitis. He was admitted due to suspected leukemia with a white blood cell (WBC) count of 63,000 cells per microliter, neutrophil 21.4%, and lymphocyte 75.3%. He was subsequently referred to another hospital and diagnosed with pertussis pneumonia and leukemoid reaction with lymphocyte predominate at the third hospital, 11 days after the onset date. He received azithromycin and DTP vaccination and recovered.

The overall attack rate was 0.6% (15/2,394), highest in Village 5 (1.6%). Children aged 1–4 years were most affected (3.4%), followed by those under 1 year (2.9%). The attack rate among household and community contacts was 21.1% (4/19) and 11.1% (2/18), respectively. Regarding DTP vaccination in children aged 0–7 years, the attack rate was highest in the unvaccinated (10.8%), lower in the incomplete (6.6%), and 0.0% in the complete group (Table 1).

Source of Infection and Risk Factors of Disease Transmission

Seven days after the index case's onset, some household and community contacts developed symptoms. The index case shared a room with his family, spent time with his babysitter and grandmother, and slept with his parents. They rarely wore masks, frequently played and ate together, and shared personal items.

Table 1. Attack rate of pertussis cases by village, gender, age group, DTP vaccination status, and type of contact in Villages 4-6, Muang Tia Subdistrict, Mae Lan District, Pattani Province, September–December 2023

Classification		Population	Cases	Attack rate (%)
Village	Village 4	969	5	0.5
	Village 5	639	10	1.6
	Village 6	786	0	0.0
	Total	2,394	15	0.6
Gender	Male	1,194	8	0.7
	Famale	1,200	7	0.6
Age group (years)	<1	35	1	2.9
	1–4	177	6	3.4
	5–9	238	3	1.3
	10–19	490	2	0.4
	20–29	401	0	0.0
	30–39	342	2	0.6
	40–49	228	0	0.0
	50–59	225	1	0.4
	≥60	258	0	0.0
DTP vaccination status in children aged 0–7 years	None	37	4	10.8
	Incomplete	79	5	6.3
	Complete	174	0	0.0
Type of contact	Household	19	4	21.1
	Community	18	2	11.1
	Hospital	31	0	0.0

DTP: diphtheria, tetanus, pertussis.

As shown in Figure 2, cases in Villages 4 and 5 developed symptoms concurrently without obvious direct contact with one another (Figure 3). Among 15 cases, 52.2% had identified sources, including household and community contacts. The remaining 47.8% had unidentified sources, including visits to crowded places like markets, where two confirmed cases were vendors. Mask-wearing was rare among vendors and clients. No URI clusters were reported in two related schools, and no cases had a travel history to epidemic districts.

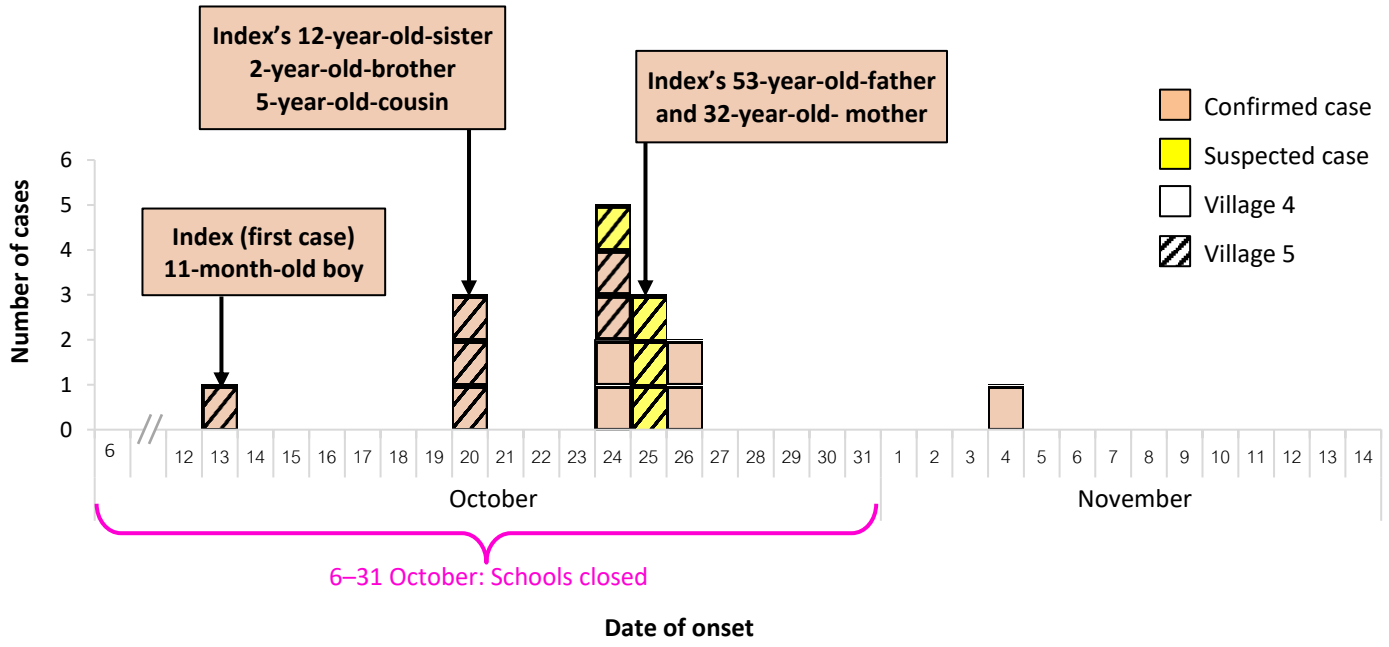
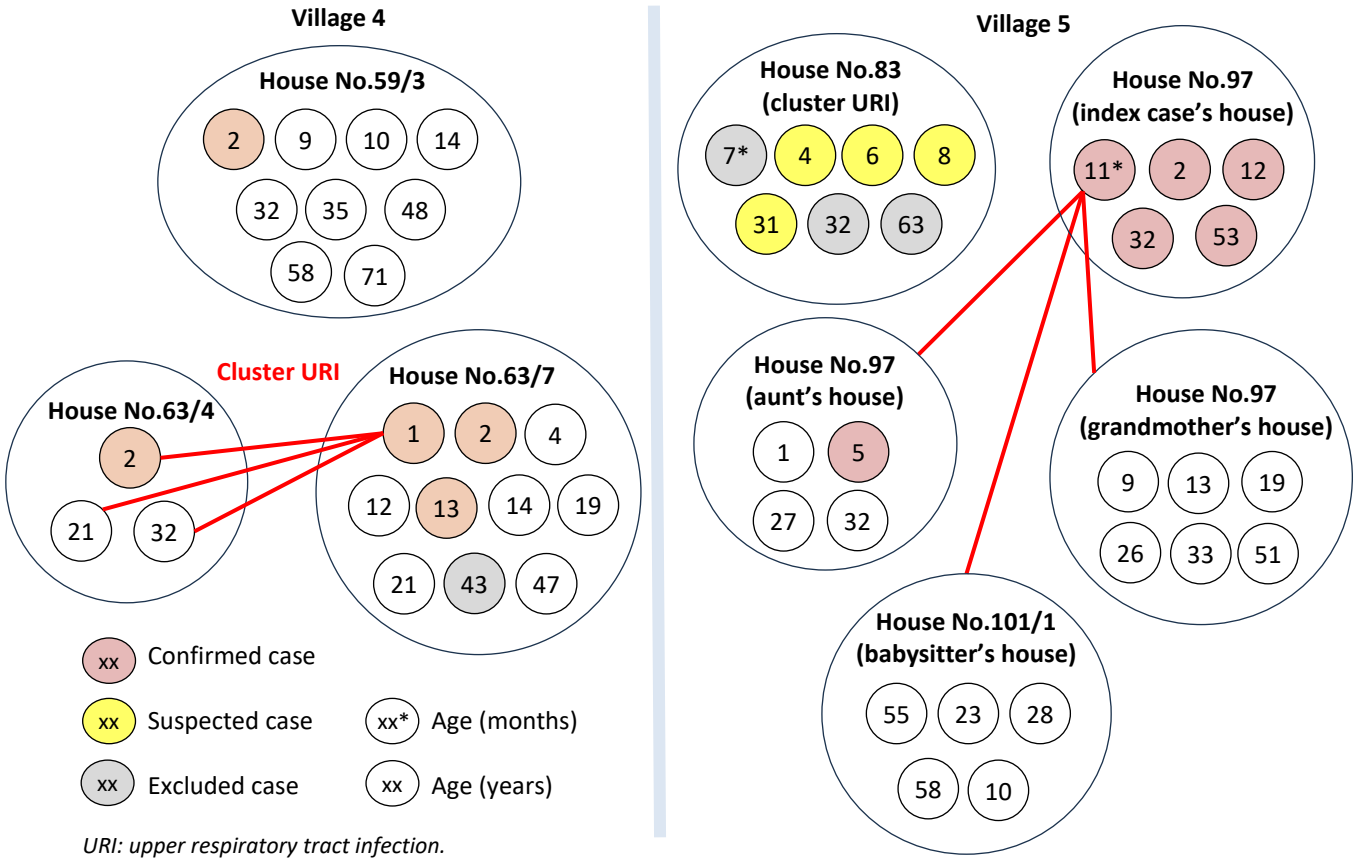


Figure 2. Number of pertussis cases in Villages 4-6, Muang Tia Subdistrict, Mae Lan District, Pattani by onset date during 22 Sep–16 Dec 2023 (n=15)



URI: upper respiratory tract infection.

Figure 3. Linkage of pertussis cases in Villages 4 and 5, Muang Tia Subdistrict, Mae Lan District, Pattani Province, September–December 2023

Vaccine Coverage in the Community

In 2023, DTP3 vaccine coverage was low across many districts in Pattani Province, including Mae Lan District (64.3%). In Mae Lan District, Muang Tia Subdistrict had the lowest DTP3 vaccine coverage (54.3%), with Villages 4–6 showing particularly low rates (68.2%, 35.7%, and 35.7%, respectively) as shown in Figure 4.

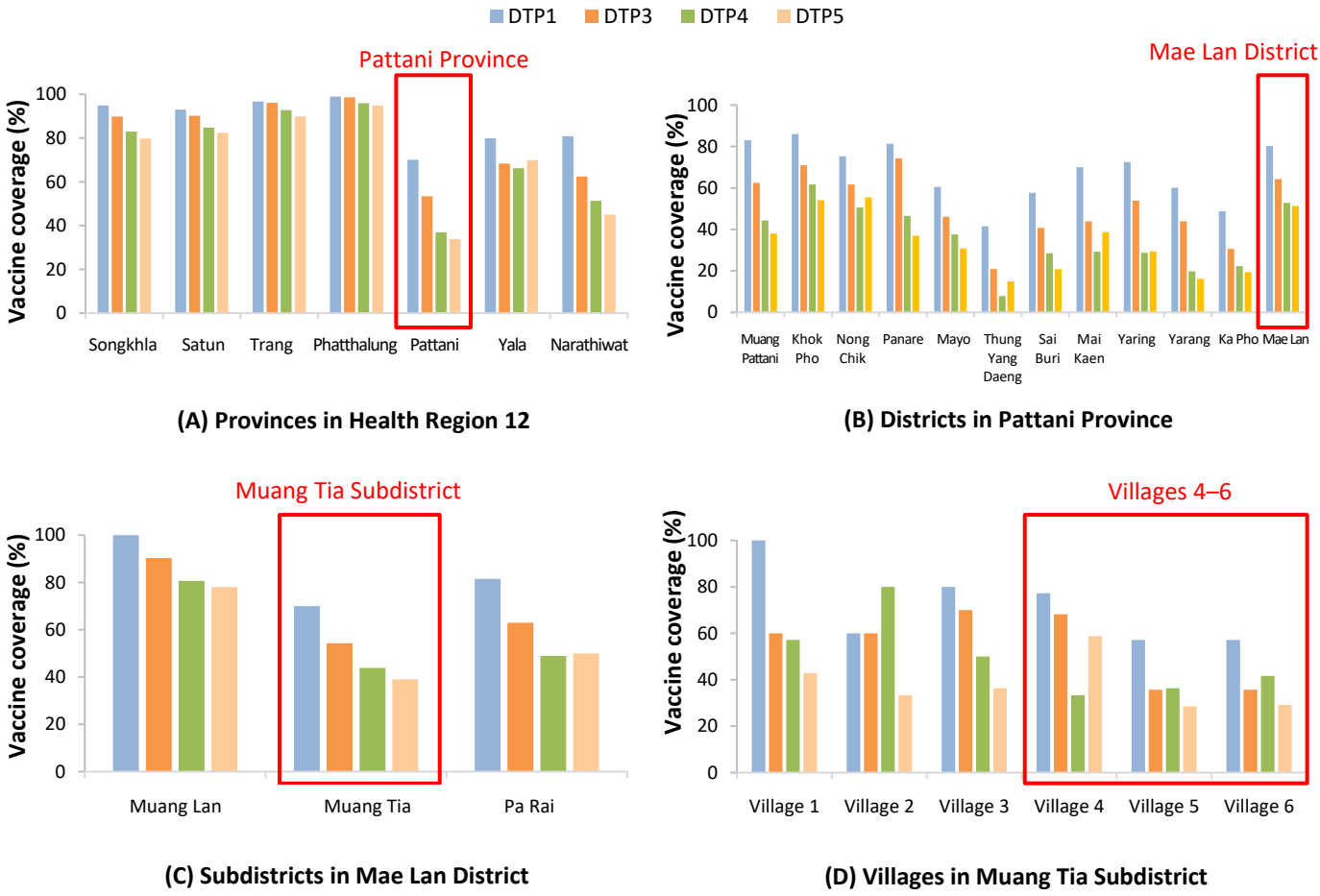


Figure 4. DTP vaccine coverage for Doses 1, 3, 4, and 5 in Thailand in 2023 by province in Health Region 12 (A), districts in Pattani Province (B), subdistricts in Mae Lan District (C), and villages in Muang Tia Subdistrict (D), with study areas highlighted

Regarding the vaccination survey in Villages 4–6, we surveyed 84.0% (42/50) of children aged 0–1 year from 81.8% (36/44) of households with children aged 0–1 year, along with 2 households with pregnant women. Age-appropriate DTP coverage in children aged 0–1 year was lowest in Village 4 (15.4%), followed by Villages 6 and 5 (Table 2). Interviews revealed that low coverage was due to parents' fear of fever or adverse reactions, concerns about missing work, low awareness of immunization benefits, and caregiver migration.

Table 2. Age-appropriate DTP vaccine coverage in children aged 0–1 year from the survey in Villages 4–6, Muang Tia Subdistrict, Mae Lan District, Pattani Province

Village	Age-appropriate DTP vaccine coverage in children aged 0–1 year*	95% CI
4	15.4% (2/13)	1.9–45.4
5	40.0% (4/10)	12.2–73.8
6	25.0% (3/12)	5.5–57.2
Total (weighted)	**25.0%**	**10.4–39.6**

**Seven children aged less than two months were excluded (two, three, and two persons from Villages 4, 5, and 6).*
CI: confidence interval.

Post-hoc Analysis of Sensitivity and Specificity of National and Modified Pertussis Definitions

The national definition had a sensitivity of 9.09% (95% CI 0.2%–41.3%) and specificity of 88.9% (95% CI 70.8%–97.6%). The modified definition had a sensitivity of 81.8% (95% CI 48.2%–97.7%) and specificity of 70.4% (95% CI 49.8%–86.2%), as shown in Figure 5.

A) National definition:

Cough ≥2 weeks AND a typical pertussis symptoms (paroxysmal cough, inspiratory whooping, post-tussis vomiting, apnea)

	PCR positive	PCR negative
Met definition	1	3
Did not meet	10	24

Sensitivity 9.09% (95% CI 0.23%–41.28%)
Specificity 88.89% (95% CI 70.84%–97.65%)

B) Modified definition:

1. Cough (any duration) AND a typical pertussis symptom (paroxysmal cough, inspiratory whooping, post-tussive vomiting, cyanosis, apnea) OR

2. Close contact with a confirmed case AND a URI symptom (cough/rhinorrhea/sore throat)

	PCR positive	PCR negative
Met definition	9	8
Did not meet	2	19

Sensitivity 81.82% (95% CI 48.20%–97.72%)
Specificity 70.37% (95% CI 49.82%–86.25%)

URI: upper respiratory tract infection. PCR: polymerase chain reaction.

Figure 5. Sensitivity and specificity of national (A) and the modified (B) pertussis case definitions

Action Taken

Post-exposure prophylaxis and treatment were provided to all 68 close contacts and 16 individuals who met case definitions while awaiting laboratory results, following the same regimen. These included azithromycin for adults (500 mg orally on day 1, followed by 250 mg daily on days 2–5) and erythromycin for children (40 mg/kg/day orally, divided into four doses for 14 days). Catch-up DTP vaccination was offered to 49 children, but only four parents/guardians accepted. Two pregnant women were offered the Tdap vaccine, but neither received it. Disease surveillance was set up; however, we identified no more pertussis cases until 16 Dec 2023. We also attended meetings with the Pattani Provincial Communicable Disease Committee and the Communicable Disease Control Unit Team from the provinces of Pattani, Yala, and Narathiwat to present findings, propose surveillance definitions, and discuss control measures.

Discussion

Bordetella pertussis was confirmed as the cause. Confirmed cases manifested fewer typical symptoms compared to other studies, where paroxysmal cough ranged from 63–90%, whooping cough 8–79%, and post-tussive vomiting 42–53%.[19] In our study, only 36% had a cough lasting 2 weeks. As a result, relying on the national definition may delay case identification. In contrast, the modified definition, which focuses on typical symptoms rather than cough duration, demonstrated higher sensitivity. This approach could enable earlier detection and reduce transmission, particularly in low DTP vaccination areas.

An 11-month-old index case, diagnosed with a leukemoid reaction and pertussis pneumonia, highlights the severe risk in children. A leukemoid reaction is a nonleukemic WBC elevation above 50,000 cells per microliter. This can be typically found in infants and is linked to a tenfold higher risk of death.[20] Children under 1 year are particularly vulnerable to pertussis complications, with 33% requiring hospitalization and 22% developing pneumonia.[1,2] Despite early medical attention, the index case's diagnosis occurred 11 days after onset. The modified definition could aid early diagnosis. Healthcare providers should suspect pertussis in respiratory infections, considering symptoms, DTP history, and WBC results.

This pertussis outbreak was likely due to low DTP coverage below the WHO recommendation of 90%.[13] Our findings highlighted low DTP3 coverage and inadequate age-appropriate DTP coverage among children aged 0–1 year in Villages 4–6. The highest attack rates were among unvaccinated and incompletely vaccinated groups, with a 2.9% rate in children under 1 year. Studies showed that children aged 0–1 year are highly vulnerable and benefit from completing three DTP doses, with efficacy rising from 55.3% for one dose to 83.5% for three doses.[21]

Low vaccine coverage was influenced by factors such as fear of side effects, low awareness, and caregiver migration. This aligns with studies highlighting parental concerns about fever and pain, particularly in low-health-literacy areas.[14,22] Improving coverage in children aged 0–1 year through early immunization starting at 6 weeks of age, with subsequent doses 4 weeks apart, is essential for achieving herd immunity.[23,24] In addition, strategies should include post-immunization follow-up, awareness campaigns, and healthcare providers' training to address parental concerns through easy-to-understand educational materials and community engagement. Offering DTaP instead of DTwP could reduce side effect concerns, despite its higher cost and slightly lower efficacy.[10,25–27] Additionally, ensuring pregnant women receive Tdap or aP at 27–36 weeks of gestation is crucial to protect newborns.[8]

Household and community contacts played a key role in disease transmission, as individuals shared living spaces and items while rarely wearing masks. High attack rates were observed among these contacts, consistent with studies showing 70–90% transmission in households and up to 50% in the community.[28–31] The simultaneous clusters in Villages 4 and 5 suggested widespread community transmission. Adolescents and adults with milder symptoms can still transmit pertussis.[32,33] The index case likely contracted the infection from family members with unrecognized symptoms, as family members are often the source in infants.[34] These findings underscore the importance of public health measures, including distancing, mask-wearing, and hand washing, to control outbreaks, particularly in crowded areas.

Post-exposure prophylaxis is crucial in controlling pertussis spread, particularly in high-risk settings such as households, healthcare facilities, and communities. Macrolides and co-trimoxazole should be administered within 21 days of exposure, regardless of vaccination history.[4] These agents effectively eliminate *Bordetella pertussis* from the nasopharynx, reduce duration, severity, and transmission.[4,5] Prophylaxis is recommended for all household contacts and high-risk individuals such as infants, pregnant women, or those with pre-existing conditions.[4,5]

Limitations

Our study had limitations. First, nasopharyngeal swabs were not performed on all suspected cases or contacts due to a lack of symptoms and cooperation, potentially underreporting cases. However, post-exposure prophylaxis and prevention measures were administered. Secondly, only 38 individuals underwent *Bordetella pertussis* PCR testing, which was lower than the required sample size, resulting in insufficient statistical power. Lastly, although the vaccination survey successfully included 84% of children aged 0–1 year, we missed eight children. This could lead to either an under- or over-estimation of the age-appropriate DTP coverage.

Recommendations

The Division of Vaccine-Preventable Disease, Provincial Communicable Disease Committee, and District Health Board should enhance DTP coverage among children aged 0–1 year to over 90%. This can be achieved through local collaboration, post-immunization follow-up, and increased awareness. Further studies should assess whether DTaP is worth investing in compared to DTwP.

To prevent severe disease among children aged 0–1 year, DTP vaccination should start at 6 weeks of age with 4-week intervals.[23,24] Pregnant women should receive Tdap or aP at 27–36 weeks of gestation.

In low-vaccination areas, a modified pertussis definition should be established to enhance case detection sensitivity. Healthcare providers should prioritize pertussis in differential diagnoses, especially in cases of leukemoid reactions. Furthermore, distancing, mask-wearing, and hand-washing measures should be emphasized in crowded places to prevent future outbreaks.

Conclusion

A pertussis outbreak in Muang Tia Subdistrict, Pattani Province, affected at least 11 confirmed and 4 suspected cases, including one hospitalized pneumonia case with no deaths. The attack rate in children under 1 year was 2.9%. Key factors included low vaccination coverage, with only 25.0% of children aged 0–1 years receiving age-appropriate DTP vaccine. High community transmission was also observed, with a pertussis positivity rate of 50%. A modified pertussis case definition demonstrated higher sensitivity (81.8%) compared to the national definition (9.1%). Increasing vaccine coverage to 90% and using a modified pertussis definition in low-vaccination areas are recommended.

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Conflicts of Interest

The authors had no conflicts of interest.

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

During the preparation of this work, the authors used ChatGPT to correct grammar. After using this tool/service, the authors reviewed and edited the content as needed and took full responsibility for the content of the publication.

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