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Challenging Response to Whooping Cough: Insights from Low Childhood Vaccine Coverage Areas in Narathiwat Province, Thailand 2024

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Abstract

Pertussis, caused by the *Bordetella pertussis* bacteria, remains a global health concern, particularly affecting incompletely or unimmunized infants. This study, conducted in Narathiwat Province, Southern Thailand, has three aims: to describe the epidemiological characteristics of the pertussis outbreak, to assess the vaccine coverage status across all districts, and to describe the response of the Narathiwat Provincial Public Health Office's Emergency Operations Center (Narathiwat EOC) to the outbreak. Between September 2023 and May 2024, Narathiwat EOC recorded 714 pertussis cases, with a male-to-female ratio of 1:0.9 and a median (interquartile) age of 2 (1–6) years. Over half (53.2%) of the cases had not been vaccinated with the diphtheria-tetanus-pertussis (DTP) vaccine. The lowest DTP coverage was observed in the districts of Si Sakhon, Rueso, Bacho, Chanae, and Cho-airong, which also reported the highest number of cases. Major challenges for the Narathiwat EOC included managing dynamic data, creating targeted strategies, effectively vaccinating children and mothers, identifying active cases, and administering chemoprophylaxis. The Narathiwat EOC addressed these challenges by implementing real-time data collection, risk-based control measures, innovative vaccination campaigns, targeted case-finding programs, and streamlined distribution of chemoprophylaxis. Effective strategies included addressing vaccine refusal by providing information on managing post-vaccination fever and engaging local advocates, and considering routine maternal immunization to protect infants in areas with low vaccine coverage, which could have significant policy implications at both the local and national levels.

Keywords: pertussis, whooping cough, Emergency Operations Center, Narathiwat, Southern Thailand, diphtheria-tetanus-pertussis vaccine, low vaccine coverage

Introduction

Pertussis, commonly known as whooping cough, is a highly contagious bacterial infection caused by the *Bordetella pertussis* bacteria. Despite the availability of vaccines, it remains a global public health concern, especially for infants who have not completed their vaccination schedule or are unimmunized, resulting in compromised herd immunity and community outbreaks.[1] After a 6–20 day incubation period, symptoms begin with a mild catarrhal phase, progressing to severe coughing paroxysms with characteristic "whooping" sounds.[2] Transmission primarily occurs through respiratory droplets.[3] Pertussis poses severe risks, particularly to infants aged under one year, potentially leading to pneumonia, encephalopathy, or death. Maternal vaccination with the acellular pertussis (aP) vaccine during pregnancy can help to reduce these risks in infants.[4] Chemoprophylaxis with macrolide antibiotics can also reduce the severity of infection.[5] The primary diphtheria-tetanus-pertussis (DTP) vaccine series remains the most effective prevention method.[3]

Globally, over 60,000 pertussis cases were reported in 2022, with an incidence rate of 9.2 per million

population, reflecting the disease's significant morbidity and mortality.[6] In Southeast Asia, the incidence increased from 2014 to 2017, peaking at 20 cases per million, declining during the COVID-19 pandemic, but rebounding to 5.8 in 2023.[7] Thailand experienced a similar trend, with pertussis cases rising until 2018 (0.26 per 100,000) before declining to a low in 2021 (0.01 per 100,000) amid COVID-19.[8] The Ministry of Public Health (MOPH) provides the DTP vaccine for free as part of Thailand's expanded immunization program, achieving over 90% coverage since 2005.[9] However, the three southern border provinces—Yala, Pattani, and Narathiwat—continue to face pertussis challenges, with cases occurring nearly every year since 2012 due to the low DTP coverage.[8] Vaccine refusal among parents, driven by concerns over halal content and potential side effects, contributes to this challenge.[10–13]

Since September 2023, pertussis outbreaks have affected all three southern border provinces. Though Narathiwat Province reported fewer cases, it had the highest number of fatalities, with three deaths, prompting the establishment of the Narathiwat Provincial Public Health Office's Emergency Operations Center (Narathiwat EOC). The Narathiwat EOC coordinates case tracking, resource allocation, and community education to control outbreaks in collaboration with health agencies. This study has three aims: to describe the epidemiological characteristics of the pertussis outbreak, to assess vaccine coverage across districts of Narathiwat Province, and to describe the response of the Narathiwat EOC to the outbreak.

Methods

Outbreak Description in Narathiwat Province, Thailand

To describe the magnitude and epidemiological characteristics of pertussis cases regarding the pertussis outbreak from 1 Sep 2023 to 31 May 2024, the Narathiwat EOC used a modified clinical case definition from the national pertussis surveillance case definition in Thailand, 2020.[14] This definition included individuals with a cough lasting one week or more and at least one of the following clinical criteria: (1) paroxysmal coughing, (2) post-tussive vomiting, (3) inspiratory whooping, or (4) apnea. A probable case was defined as a suspected case who had contact with a confirmed pertussis case. A confirmed case was any individual with laboratory confirmation of pertussis by positive reverse transcription polymerase chain reaction (RT-PCR) technique.

A high-risk contact (HRC) was defined as an individual who had been in contact with at least a suspected case within the household or contact with another person in the community within one meter for at least five minutes without wearing a mask.

We collected data from an online platform created by the situation awareness team, which was tasked with collecting case reports from all districts and entering them online. The collected data included variables such as age, gender, address, laboratory results, symptoms, onset date, treatment status, DTP vaccination history, history of contact, and chemoprophylaxis status for contacts. Subsequently, the data were recorded using Microsoft Excel, checked for completeness and accuracy, and cleaned before data analysis.[15] In the case of discrete variables, frequencies with percentage were calculated. For continuous variables, medians with interquartile range (IQR) were calculated.

Vaccine Coverage Status

We collected data on vaccine coverage across all 13 districts in Narathiwat Province for 2023 from the Health Data Center of the MOPH, Thailand. This data detailed vaccine coverage for the year preceding the outbreak, covering the period from October 2022 to September 2023.

Response of the Narathiwat EOC to the Pertussis Outbreak

We described the challenges faced by the Narathiwat EOC in controlling the pertussis outbreak and their strategies in overcoming them, including data management, accelerated vaccination, and outbreak control strategies. We employed risk analysis using a matrix table correlating case numbers with the DTP vaccine coverage by district. Data were collected from weekly Narathiwat EOC meetings on the pertussis response, and various reports, including meeting notes, minutes, and incident command reports, between October 2023 and May 2024.

Ethics

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 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, who will be in charge of overseeing data disposal post-publication.

Results

Outbreak Description in Narathiwat Province, Thailand

A total of 714 pertussis cases were identified, including 279 confirmed cases, 47 probable cases, and 388

suspected cases. The male-to-female ratio was 1:0.9. The median (IQR) age was 2 (1–6) years. The incidence rate over the 9-month outbreak period in Narathiwat Province was 89.3 per 100,000 population. There were three deaths, resulting in a fatality rate of 0.4%. Of these, two were infants under one month who had not reached the age to receive their DTP vaccine according to the expanded program on immunization guidelines.

Nearly half (53.2%, 380/714) of all cases had never received the DTP vaccine, while 178 (24.9%) had incomplete DTP vaccination, and 50 (7.0%) had completed the 5-dose DTP vaccination series. The majority of cases occurred in children aged 1–6 years and under one year, representing 52.0% (371/714) and 29.7% (212/714) and 52.8% and 70.5% were unvaccinated, respectively (Figure 1).

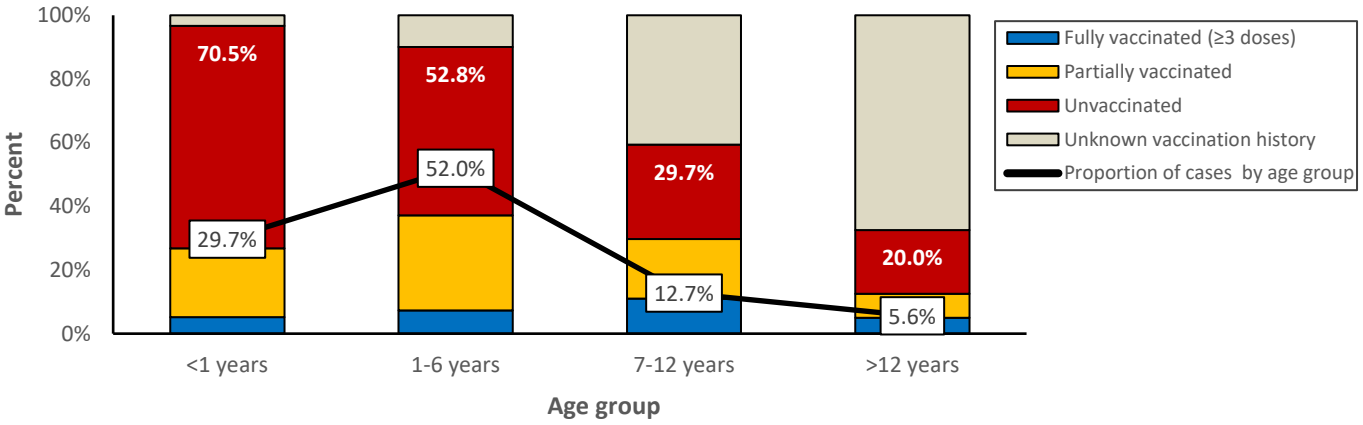
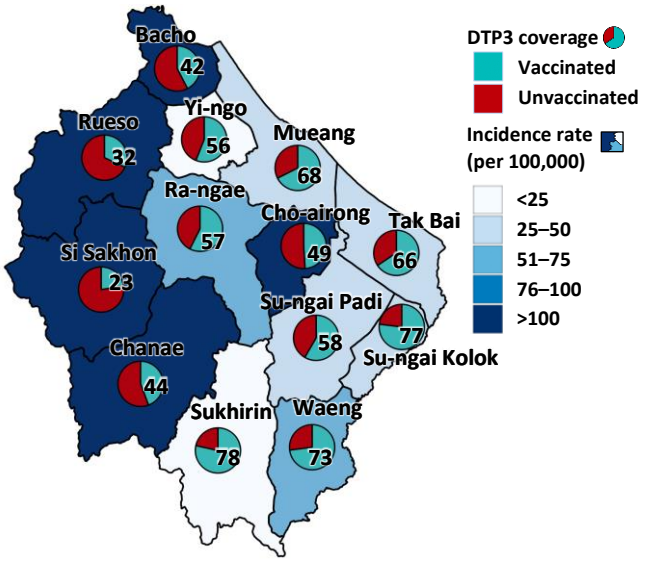


Figure 1. Percentage of cases by diphtheria-tetanus-pertussis vaccine status and age group during the pertussis outbreak from September 2023 to May 2024, Narathiwat Province, Thailand

Vaccine Coverage

Before the outbreak, DTP vaccine coverage in Narathiwat Province in 2022 was low (77.4%, 55.7%, 48.0%, and 40.4% for the 1st, 3rd, 4th and 5th doses, respectively). The lowest 3rd dose coverage occurred in Si Sakhon, Rueso, Bacho, Chanae, and Cho-airong districts, which also reported the highest incidence (Figure 2).



DTP3: diphtheria-tetanus-pertussis third dose

Figure 2. Incidence rate (per 100,000) during the pertussis outbreak from September 2023 to May 2024, and baseline diphtheria-tetanus-pertussis vaccine coverage before the outbreak (data from October 2022 to September 2023) by district, Narathiwat Province, Thailand

Response of the Emergency Operations Center (EOC) to the Pertussis Outbreak

The Narathiwat EOC faced significant challenges in managing the pertussis outbreak due to data management across multiple districts and updated needs, disparate outbreak risks across districts, and personnel constraints. The following results cover the problems encountered, strategies used to address them, and solutions implemented.

Managing data dynamics

The Narathiwat EOC faced a major challenge with a surge in pertussis cases spreading across multiple districts. Previously, weekly patient reports caused delays in obtaining daily updates on case numbers and clinical severity, making it difficult to assess health capacity and resources, including the use of isolation rooms, respirators, and medications. To resolve this, an online platform was implemented for daily reporting by district communicable disease control units (CDCUs) reported cases and daily updates on severity, treatment, hospital status, number of HRCs, and their chemoprophylaxis status. Access to reports and data was restricted to specific usernames via the organization's email. Additionally, all data were automatically collected and analyzed using a real-time dashboard, which displayed various indicators such as case numbers, their characteristics, person, and place (district level), epidemic curves, disease severity (including death and number of intubated cases), and chemoprophylaxis coverage for HRCs. Following these

improvements, the Narathiwat EOC received prompt daily updates, enabling timely assessment of outbreak severity, while local CDCUs could address district-specific needs with tailored responses. Hospital administrators also used this data to manage health resources efficiently, ensuring coordinated efforts in resource allocation and outbreak control.

Tailored risk-based strategies

Many districts struggled with outbreak management and were unsure about the intensity of control measures and whether to prioritize vaccination or active case finding (ACF) due to the need for specialized public health personnel. To address this challenge, the Narathiwat EOC conducted a risk analysis using a matrix table that correlated case numbers with DTP (3rd dose) vaccine coverage by district. This analysis allowed them to prioritize districts based on risk levels, indicated by color: red for urgent, orange for high risk, yellow for medium risk, and green for low risk (Figure 3). Tailored strategies were implemented, setting specific goals for each district such as weekly DTP vaccine coverage rates and ACF targets based on risk level (Table 1). The Narathiwat EOC reviewed and adjusted these strategies every 2–3 weeks during their weekly meetings. This approach increased confidence in disease control efforts and ensured clear targets were achieved. Additionally, the Narathiwat EOC effectively monitored the plan's implementation at the provincial level.

Risk assessment matrix		Number of pertussis cases criteria				
		1	2	3	4	5
DTP3 coverage criteria	5	Medium	High	Urgency	Urgency	Urgency
	4	Medium	High	High	Urgency	Urgency
	3	Low	Medium	High	High	Urgency
	2	Low	Medium	Medium	High	High
	1	Low	Low	Low	Medium	Medium

1. Number of pertussis cases criteria		2. DTP3 vaccine coverage criteria	
• No cases found	1 point	• Vaccine coverage >90%	1 point
• 1–10 cases found	2 points	• Vaccine coverage 81–90%	2 points
• 11–20 cases found	3 points	• Vaccine coverage 71–80%	3 points
• 21–30 cases found	4 points	• Vaccine coverage 61–70%	4 points
• >30 cases found	5 points	• Vaccine coverage ≤60%	5 points

DTP3: diphtheria-tetanus-pertussis third dose

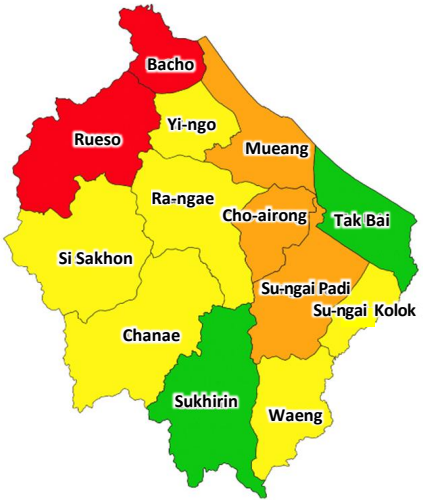


Figure 3. Risk assessment matrix correlating pertussis case numbers with baseline diphtheria-tetanus-pertussis vaccine coverage by district, showing risk levels with color-coded categories used by the Narathiwat EOC during the pertussis response

Table1. An example of an implementation table for tailored strategies conducted on 1 Dec 2023, showing specific goals for each district, including weekly diphtheria-tetanus-pertussis vaccine coverage rates and active case finding targets based on risk levels

Operations \ Risk level	Urgency	High	Medium	Low
Active case finding	Target area • Villages with the **highest number of index cases** in the past 6 weeks (two cycles of the longest incubation period), with at least 3 villages. • Childcare centers, schools, or other educational institutions that had index cases in the past 6 weeks, with at least 3 institutions.	Target area • Villages with the **highest number of URI cases** in the past 6 weeks. • Villages with the **highest number of index cases** in the past 6 weeks, with at least 2 villages. • **Childcare centers, schools,** or other educational institutions that had index cases in the past 6 weeks, **with at least 1–2 institutions.**		Target area • Villages with the **highest number of URI cases** in the past 6 weeks at least 3 village.
Vaccination	• Increase DTP vaccination mop-up efforts **by 10% per week.** Implement a proactive vaccination schedule in the community at least 5 days per week. • Open vaccine service units every day.	• Villages with the **highest number of index cases** in the past 6 weeks (two cycles of the longest incubation period), with at least 3 villages.		• Increase DTP mop-up vaccinations **by more than 5% per week.** Implement proactive vaccination campaigns in the community at least once per week.

URI: upper respiratory infection. DTP: diphtheria, tetanus, and pertussis vaccine.

Targeted active case finding

In the early stages of the outbreak in September 2023, only the Bacho District CDCUs conducted an ACF in the community and identified 20 suspected cases. Many districts were uncertain about how to target high-risk areas to improve the effectiveness of the ACF. To address this, the Narathiwat EOC instructed them to use patient data from district hospital information systems to identify high-risk areas. They focused on patients who had visited a hospital with upper respiratory infection (URI) in the past month, with diagnoses based on relevant ICD-10 codes. These codes targeted patients diagnosed with URI such as J00 (common cold), J40 (bronchitis), and J209 (acute bronchitis) within the past month from district hospital information systems. Upon identifying clusters of URI in a village, efforts were concentrated in specific locations such as community childcare centers and schools. As a result, efforts in all districts involved 282 individuals, with 67 (23.7%) pertussis cases found.

Vaccinating children and beyond

According to the Narathiwat EOC, following the guidelines from the MOPH Thailand, an accelerated DTP vaccination campaign in January 2024 using a mop-up approach was launched. This involved blanket vaccination for the target group of children aged under seven years, regardless of their previous vaccination history, targeting approximately 49,000 individuals. Initially, the campaign relied solely on district healthcare centers, achieving only 6.0% coverage with an average weekly increase in vaccination rates of 0.2–0.5%. This slow rate was inadequate for achieving herd immunity during outbreaks. To address this, mobile DTP vaccination units conducted proactive field visits to around 470 communities and 50 schools or daycare centers. Ultimately, the accelerated DTP mop-up campaign achieved 32.9% coverage after the Narathiwat EOC closed, with a weekly increase in rate of 2.1% (Figure 5).

During the outbreak, two infants aged under one month, who were not eligible for the DTP vaccine, died. Their mothers had not received the acellular pertussis (aP) vaccine, as it was optional and not provided for free, leading to many mothers potentially missing it. This contributed to challenges in preventing infection and reducing infant mortality during the outbreak. To address this issue, the Narathiwat EOC collaborated with the Maternal Child Health Board, which oversees maternal and child healthcare in the province. The board expedited a policy to accelerate aP vaccinations through antenatal care service units. From 3 Dec 2023 to 5 May 2024, these units administered aP vaccinations in Narathiwat Province to all pregnant women starting from 16 weeks of gestation, without waiting for scheduled antenatal care examination days. Approximately 3,200 individuals were targeted. This initiative achieved a vaccination coverage rate of 100% among the target group, and no further deaths were reported following this achievement (Figure 5).

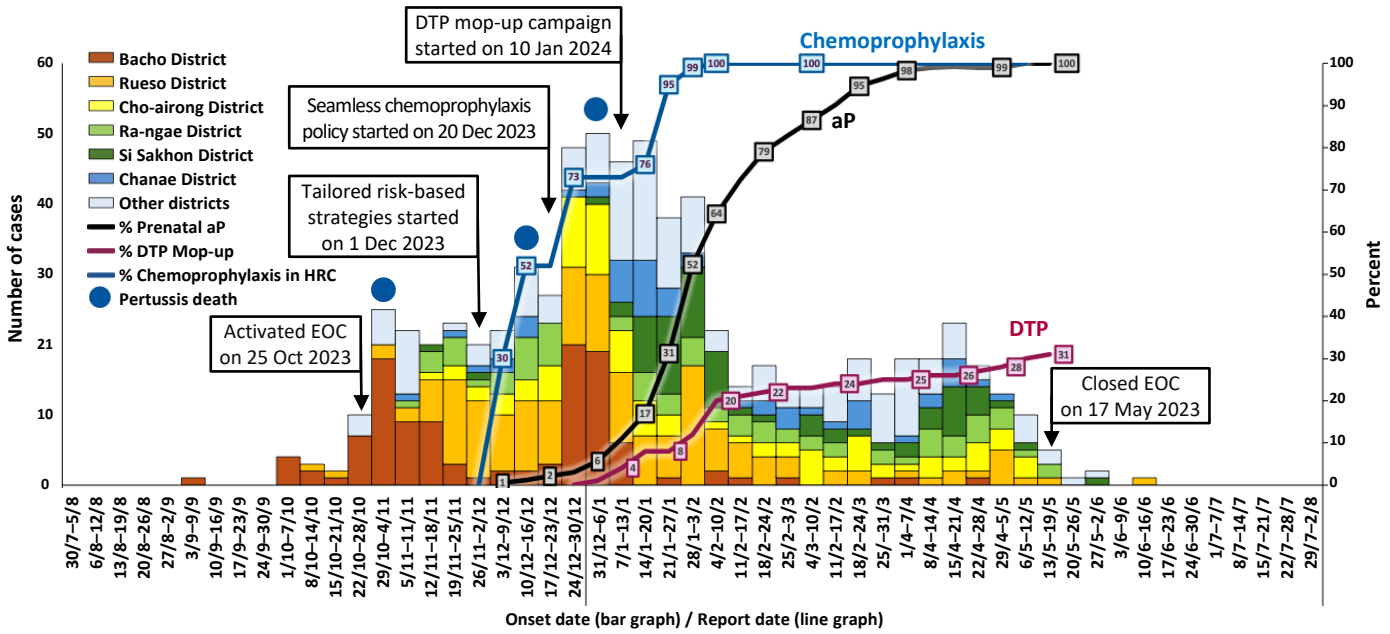


Figure 5. Number of pertussis cases by onset date (seven-day counts) and implemented control measures, e.g., chemoprophylaxis in high-risk close contacts (HRCs), prenatal acellular pertussis (aP), and diphtheria-tetanus-pertussis (DTP) vaccine mop-up, by Narathiwat Emergency Operations Center (EOC) during the pertussis response between September 2023 and May 2024, Narathiwat Province, Thailand (n=714)

Seamless chemoprophylaxis

When active case finding and case tracing were conducted according to the control measures, individuals meeting the case definition and their HRCs were promptly given macrolide chemoprophylaxis, even before RT-PCR laboratory results for pertussis were confirmed. However, a challenge arose because these antibiotics required a doctor's prescription, and HRCs needed to make appointments to receive the medication at a hospital. This led to missed appointments, resulting in a chemoprophylaxis receipt rate of only 30% in November 2023, the initial period. To address this, the Narathiwat EOC implemented a policy allowing physicians to pre-order macrolide chemoprophylaxis at hospitals, facilitating distribution during fieldwork with labeled instructions. Community nurse practitioners and CDCUs provided guidance on usage, ensuring immediate access during field operations. As a result, 97.6% of HRCs (2,360 out of 2,419) received chemoprophylaxis, achieving 100% completion before the Narathiwat EOC closed (Figure 5). Almost all HRCs who received macrolides avoided pertussis, with only three developing secondary infections.

Discussion

Low Vaccine Coverage and Vaccine Hesitancy

The three southern border provinces have experienced low vaccination coverage, particularly for the DTP and the measles, mumps, and rubella vaccines, which have remained below 90% over the past decade. Specifically, Narathiwat Province had a baseline DTP (3rd dose) coverage of around 55% last year, hindering herd immunity.[16] When outbreaks of vaccine-preventable diseases such as pertussis and measles occur, they quickly spread to neighboring provinces, primarily affecting infants, who suffer the highest rates of mortality and morbidity.[17–19] Malnutrition in these areas exacerbates the severity of symptoms during outbreaks.[20] These provinces, distinct in religion and culture, have a predominantly Muslim population (about 80%). Adherence to religious customs, especially regarding halal products, leads to suspicions about vaccine ingredients.[21,22] Concerns about vaccine safety, particularly the fear of fever post-vaccination, contribute to vaccine refusal among parents. However, many parents worry that if their child gets a fever after vaccination, they will be forced to take time off work and, therefore, their income will suffer.[11–13] Economic challenges in Narathiwat Province, including low economic growth and education levels, may indirectly contribute to vaccine hesitancy.[23,24] Studies from Italy, India, Pakistan, and Malaysia highlight similar issues, underscoring the need for a collaborative effort from various stakeholders beyond the MOPH to address these economic concerns and support vaccine uptake.[25–28]

Acceptance of Prenatal Acellular Pertussis Vaccine (aP)

From this pertussis outbreak, there were two deaths; both infants were aged less than one month and their mothers had not received the aP vaccine. This underscores the crucial role of aP vaccination for pregnant women in preventing infant deaths. High vaccine effectiveness, about 90% against pertussis in infants of immunized mothers, was reported, significantly reducing hospitalization and deaths in infants aged 0–3 months.[29,30] In Narathiwat Province, almost all mothers had not received the aP vaccine because it was not provided for free at public hospitals and was only available at private clinics. However, the aP vaccine was provided to all targeted pregnant women during this outbreak for free, resulting in a 100% coverage rate, indicating high cooperation. This suggests that people may not fear vaccination entirely but are more concerned about potential complications in children that could affect their economy, aligning with previous studies in similar areas.[11–13] However, few studies conclusively link maternal aP vaccination during pregnancy with increased compliance in bringing children for scheduled DTP vaccinations.

Resistance Concerns in Chemoprophylaxis

Macrolide antibiotics, especially azithromycin and erythromycin, are recommended by the Centers for Disease Control for post-exposure chemoprophylaxis.[5] Many studies have shown that these antibiotics are effective in preventing pertussis among HRCs.[31,32] Our findings indicate that nearly all HRCs who received macrolides did not contract pertussis from an index case. However, over two thousand HRCs were given this medication during the outbreak, making it difficult to track compliance. Some individuals may not have taken the medication as prescribed, increasing the risk of macrolide-resistant *B. pertussis* (MRBP). MRBP has been reported globally, especially in mainland China, possibly due to their use of culture methods instead of molecular (RT-PCR) for diagnosis, which allows for antimicrobial resistance testing.[33,34] To monitor MRBP in Thailand, laboratory surveillance using both culture and molecular methods should be implemented, especially in areas with frequent pertussizzs outbreaks and low vaccine coverage.

Limitations

This study lacked data on maternal aP vaccination status before the outbreak, limiting the assessment of vaccine effectiveness. However, our findings suggest that the aP vaccine may reduce child mortality.

Further research on the effectiveness and cost-effectiveness of aP, especially in low-coverage, high-outbreak areas, is needed to consider government-funded vaccination for all mothers.

Recommendations

Thailand's MOPH and the National Vaccine Institute should consider policies to provide free aP vaccine to all mothers, prioritizing regions with low DTP coverage such as Narathiwat Province. To support this, the MOPH and the National Health Security Office could fund research on the vaccine's effectiveness and cost-effectiveness, facilitating its inclusion in government-funded immunizations under Universal Health Coverage. Provincial committee of Narathiwat Province should implement strategies, such as real-time online data, risk-based control measures, and targeted interventions, as a model for other regions. Collaboration among local health officers, community leaders, and the Provincial Islamic Committee is key to addressing vaccine hesitancy through combined medical and religious guidance. Additionally, local agencies and non-governmental organizations could offer support, such as paid leave or subsidies, to mitigate concerns about post-vaccination side effects and income loss, while health workers and volunteers engage communities to promote vaccination.

Conclusion

The pertussis outbreak in Narathiwat Province involved 714 cases, with a median age of 2 (IQR 1–6) years. Most cases occurred in individuals unvaccinated with the DTP vaccine (53.2%). The lowest DTP coverage was observed in the districts of Si Sakhon, Rueso, Bacho, Chanae, and Cho-airong, which also reported the highest number of cases. Narathiwat EOC addressed significant challenges in managing data, creating targeted strategies, vaccinating children and mothers, identifying cases, and administering chemoprophylaxis. In response to the outbreak, the Narathiwat EOC implemented real-time online data collection, risk-based prioritization, innovative vaccination campaigns, targeted case finding, and a streamlined chemoprophylaxis distribution. These measures facilitated a rapid response, mitigating the impact of the outbreak. To further protect vulnerable newborns, prenatal acellular pertussis vaccination is recommended in areas with low vaccination coverage.

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Conflicts of Interests

The author declares no conflicts of interest related to this work.

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