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Editorial

Should Thailand Implement an Influenza Vaccination Policy for Prisoners?

J. D. Heffelfinger, Senior Editor

An article included in this issue of *Outbreak, Surveillance, Investigation & Response* which describes an investigation of a 2023 influenza outbreak in a prison in Buriram, Thailand, that had an attack rate of 40% provides an opportunity to continue the discussion about offering influenza vaccination to incarcerated persons in Thailand.[1] Prisons are frequently overcrowded and unsanitary, and incarcerated persons are a vulnerable population, who often have poor nutrition, reduced access to healthcare and a high prevalence of chronic illnesses that increases their risk for morbidity and mortality from communicable diseases such as influenza. International human rights bodies have affirmed the obligation of states to provide access to health, including preventive, services to prisoners, and incarceration could be a good opportunity to improve the health of and provide recommended vaccines to prisoners.[2–4]

The global disease burden of seasonal influenza is high; the World Health Organization (WHO) estimates that influenza accounts for 3–5 million cases of severe illness and 290,000–650,000 deaths each year.[5] In Thailand, the incidence of influenza in 2017 was estimated to be 178 cases per 100,000 population, or almost 107,000 cases annually, and the mortality from influenza-related respiratory disease was estimated to be 6 cases per 100,000 population, or about 3,600 cases annually.[6] Vaccination is an effective way to prevent infection, morbidity and mortality from influenza. WHO recommends that persons at risk for complications from influenza, including children aged 6 months to 5 years, the elderly, persons with comorbidities, pregnant women and other groups that countries prioritize be vaccinated against influenza.[7] Thailand has a National Strategic Plan for Influenza Preparedness, and groups prioritized for vaccination include pregnant women, children 6–23 months, persons with chronic diseases, persons over 65 years, persons who have immunologic conditions, persons with obesity and those with cerebral palsy who require full-time assistance.[8]

Though prisoners have not generally been a priority group for influenza vaccination, WHO recommends that vaccination be considered for persons at high risk of severe influenza who live in congregate-living settings such as prisons.[9] The Thai Ministry of Public Health (MOPH) initiated a policy to promote vaccination of prisoners in response to increases in influenza outbreaks in prisons from 2017 to 2019 (from 17–28)—and almost 50% of the country's 143 prisons had at least one influenza outbreak between 2016–2019.[6]

Initial discussions were convened between Thailand's MOPH, Department of Corrections and Ministry of Justice and the Thai MOPH commissioned a working group to assess the cost effectiveness and budget impact of an influenza vaccination policy for prisoners.[10] Suphanchaimat and coworkers conducted a study that included a review of Thai MOPH data sources, U.S. Centers for Disease Control and Prevention data, and articles published in Thai domestic and international journals; modeling; and sensitivity analysis.[10] They found that compared with routine outbreak control, vaccinating all prisoners in Thailand's 143 prisons would decrease cases and overall costs of treatment and outbreak control, with total healthcare costs declining by almost 50%.[10] The authors concluded that the next steps for Thailand should be to convene stakeholders and determine influenza risk criteria and prioritization for vaccination.[10]

Issues in addition to cost effectiveness should be considered by Thailand as it decides whether or not to implement an influenza policy in prisons including burden of disease, influenza vaccine coverage in established priority groups, the safety and efficacy of available seasonal influenza vaccines, impact on health outcomes, logistical challenges, and possible alternative interventions that might reduce the frequency and severity of influenza outbreaks in prisons. The Thai MOPH is to be commended for taking the initial steps of being transparent about prison health, commissioning an economic analysis of influenza vaccination of prisoners, and reporting the outbreak of influenza in the prison in Buriram. Given the burden of influenza, transmission in a vulnerable population that lives in crowded conditions, and data on the cost effectiveness of influenza vaccination in prison, a good next step would be for Thailand to implement an influenza vaccine program or pilot project in prisons and assess its impact. Though the Thai MOPH budget for influenza vaccination is not nearly enough to cover all persons in Thailand's priority groups, vaccination of prisoners might be funded by or shared with one or more other Thai Ministries that would benefit from improved health and reduced outbreaks in prisons.

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Effectiveness of a Sample Pooling Strategy to Detect SARS-CoV-2, Thimphu, Bhutan, January–February 2021

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Abstract

This retrospective study aimed to evaluate the effectiveness of a pooling strategy to detect SARS-CoV-2 by comparing cycle threshold (C_t) values of pooled samples and deconvoluted samples, and its cost savings. We evaluated 2,687 pools of 5 samples (n=13,435) and 5,444 pools of 10 samples (n=54,440). Of these, 51 and 40 pools were positive from the 5- and 10-sample pools, respectively. We analyzed the C_t values of positive samples obtained through pooled testing and compared them to the C_t values of their corresponding individual positive samples. We observed a decrease in the mean C_t value by 2.0 for the 5-sample pools and by 3.6 for the 10-sample pools when the pooled samples were deconvoluted and individually tested. The drop in the mean C_t value was more pronounced in samples with a low viral load. Where the known positive COVID-19 prevalence rate was 0.13%, the pooling strategy resulted in significant savings of 89.26% for pools of 10 samples and 78.10% for pools of 5 samples when compared to individual testing. Employing this pooling approach led to substantial savings in resources and time when conducting mass screening.

Keywords: COVID-19, SARS-CoV-2, pooling, cycle threshold, RT-PCR

Introduction

The detection of the first severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) infected case on 5 Mar 2020 marked the beginning of Bhutan's comprehensive response to the coronavirus disease 2019 (COVID-19) pandemic.[1] COVID-19 testing was instrumental in Bhutan's response as part of the Test, Trace, and Treat (3T) approach for early identification of cases and to limit the transmission potential of the virus.[2]

Bhutan sealed its international borders to incoming travelers on 22 Mar 2020, all land and air routes were closed for non-emergency travel.[1] Thereafter, all individuals entering Bhutan via road and air were tested on days 3–5, days 12–14, and day 21 of quarantine prior to their release.[1] Routine testing was also initiated for individuals traveling within the country from high-risk to low-risk areas during a mandatory quarantine period of seven days. Frontline workers and a representative sample from high-risk populations were tested weekly and every two weeks, respectively. Furthermore, the Ministry of Health undertook mass screenings using the reverse transcription polymerase chain reaction (RT-PCR) technique during the phase of local transmission. Consequently, the use of COVID-19 test kits increased, which resulted in a shortage of consumables and reagents.

This sample pooling strategy was initially used to detect HIV and the hepatitis B/C virus and during the H1N1 pandemic.[3–5] The introduction of this strategy led to uninterrupted testing without requiring more laboratory personnel and/or test kits, improving efficiency, but also conserving resources.[6] On 11 Aug 2020, the Royal Government of Bhutan imposed its first nationwide lockdown in response to the escalating community transmission of COVID-19.[7] To mitigate the spread of the virus, the Ministry of Health undertook extensive testing efforts. Consequently, the demand for RT-PCR test kits surged. A sample pooling strategy was then introduced to curb the shortage of test kits, especially for COVID-19 screening during the mass testing.

Nonetheless, the impact of the pooling strategy on the cycle threshold (C_t) of individual positive tests and samples with a low viral load remained unclear.

Therefore, this paper aimed to determine the effectiveness of implementing a sample pooling approach in Bhutan during the COVID-19 pandemic.

Methods

Study Design

This study is a retrospective analysis using a sample pooling strategy implemented for COVID-19 testing at the Royal Centre for Disease Control using RT-PCR during the second nationwide lockdown in the capital city, Thimphu, between 2 Jan 2021 and 2 Feb 2021. A pool size of 5 was used for samples collected from primary contacts and quarantine facilities, while a pool size of 10 was used for samples collected from community screenings. The tests were performed using RT-PCR targeting the envelope (E) and ORF1ab genes. Positive pools were deconvoluted, and individual samples were tested for both the E and ORF1ab genes for confirmation. The C_t values of both pooled samples and individual samples were extracted from the PCR worksheet form.

Sample Collection

Nasopharyngeal swabs were collected from individuals in the community and their primary contacts, quarantine facilities, and travelers. Samples were stored in viral transport media and shipped to the Royal Centre for Disease Control for testing. Samples were processed within 24 hours from the time of their receipt.

Pooling Strategy, RNA Extraction and RT-PCR

RT-PCR was employed on two sets of pooled samples. The first group included 2,687 pools, each consisting of 5 samples, while the second group consisted of 5,444 pools with 10 samples each. Fifty µL was collected from each pool of the 5-sample pools and 25 µL from each pool of the 10-sample pools. These pooled samples were then transferred into 1.5 mL Eppendorf tubes. From each pooled sample, a 200 µL aliquot was used for RNA extraction. The RNA extraction was performed using the STANDARD M SPIN-X viral extraction kit (SD BIOSENSER, South Korea) following the manufacturer's guidelines. Ten µL of eluted RNA was subjected to RT-PCR testing using the Standard M nCoV Real-Time-Detection kit (SD BIOSENSER, South Korea), targeting the E and ORF1ab genes following the manufacturer's guidelines. Samples that tested negative in the pool testing were reported as negative, while those that tested positive were retested individually before the report was finalized.

Pooling as a Resource-saving Strategy

The cost-saving strategy was evaluated by comparing the total expenditure made for pooling strategies (5-sample pools and 10-sample pools) against the total expenditure that would have been required for individual testing, considering a testing cost of US$ 40 using Ngultrum 3000 per test during this period.

Pooling as a Time-Saving Strategy

During the study period, 18 laboratory staff were deployed: six for the RNA extraction, two for reagent preparation, two for sample sorting and labeling, and eight for sample pooling and aliquoting. The time required by 18 laboratory staff to process 94 individual samples per plates was approximately 15 minutes for sample processing, 40 minutes for RNA extraction, and an average run time of 1 hour and 30 minutes per PCR plate. However, the sample processing time for pools of 5 and 10 samples increased approximately by 45 and 85 minutes respectively, mainly due to pool preparation. The total time required for RNA extraction and the average PCR run remained the same. The time-saving strategy and testing efficiency were calculated by comparing the time required to test each plate of individual specimens (94 specimens per plate) processed with three PCR instruments per run, with the time spent for processing pools of 5 and 10 samples.

Data Analysis

Data were entered in Microsoft Excel. Descriptive statistics were used to analyze the results, and all analyses were done using Stata 13.1.

Ethics

This study was approved by the Research Ethical Board of Bhutan, Ministry of Health (REBH/Approval/2023/028).

Results

A total of 2,687 pools (n=13,435 samples) of 5-samples and 5,444 pools (n=54,440 samples) of 10-samples were evaluated in this study. Of these, 51 pools were positive from the 5-sample pools (1.89%) and 40 were positive from the 10-sample pools (0.73%). Pool-positive samples were deconvoluted and tested individually; 255 individual tests were performed from 51 pools of 5 samples and 51 (20%) individual samples were positive for SARS-CoV-2. Among the 10-sample pools, 40 pools (400 samples) were positive and among these samples, 40 (10%) were positive. The overall prevalence of the disease in laboratory setting was determined to be 0.13% (91/67,875). The C_t value of positive pools of the 10-sample pools for the E gene assay ranged from 17.3 to 42.0, and 19.25 to 40.36 for the ORF1ab gene. The C_t value of positive pools for the 5-sample pools for the E gene assay ranged from 15.5 to 42.34 and 16.92 to 40.20 for ORF1ab gene (Table 1).

Table 1. Comparison of pooled data between 10- and 5-sample pools, Thimphu, Bhutan, January to February 2021

Gene tested	Pool and deconvoluted data	Minimum C_t value	Maximum C_t value	Mean C_t value±SD
E gene	• 5 sample pools (n=51)	15.50	42.34	31.01±8.4
	• Deconvoluted samples from 5 sample pools (n=255)	15.16	40.01	28.73±8.1
	• 10 sample pools (n = 40)	17.30	42.00	34.96±7.1
	• Deconvoluted samples from 10 sample pools (n = 400)	15.05	38.27	31.16±6.7
ORF1ab gene	• 5 sample pools (n=51)	16.92	40.20	30.23±7.4
	• Deconvoluted samples from 5 sample pools (n=255)	15.12	39.08	28.42±7.4
	• 10 sample pools (n = 40)	19.25	40.36	34.30±5.7
	• Deconvoluted samples from 10 sample pools (n = 400)	15.01	36.89	30.75±5.4

C_t: cycle threshold. SD: standard deviation.

On average, when comparing the differences in C_t values between pooled samples and deconvoluted samples, the mean differences in C_t values for the pools of 5 and 10 samples were 2.0 and 3.6, respectively. When we specifically analyzed the mean C_t value differences in positive pooled samples with a C_t value ≥35, these differences became more pronounced. (Figure 1).

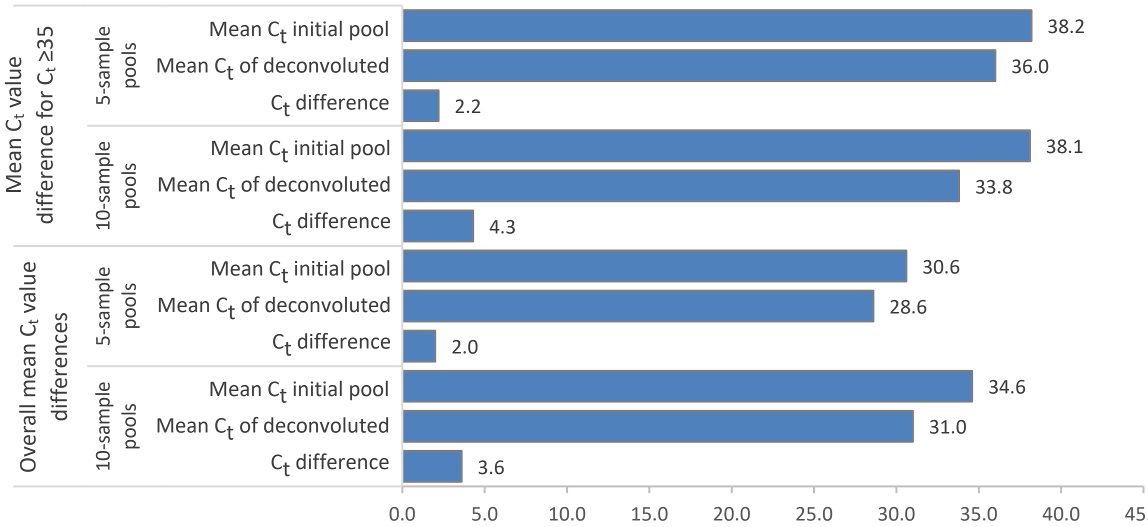

Figure 1. Comparison of overall mean cycle threshold (C_t) value differences and mean differences for C_t ≥35, Thimphu, Bhutan, January to February 2021

Conducting individual tests for all 67,875 samples would have resulted in a cost of approximately US$ 2,715,000. However, by implementing the sample pooling strategy, the cost was reduced to US$ 233,760 (pools of 10 samples) and US$ 117,680 (pools of 5 samples). The pooling approach was capable of reducing costs, by 89.26% for a pool of 10 samples and 78.10% for a pool of 5 samples, when compared to conducting individual tests (Table 2).

Table 2. Cost comparison for specimen pooling using reverse transcription polymerase chain reaction, Thimphu, Bhutan, January to February 2021

	10-sample pools	5-sample pools
Total samples	54,440	13,435
Number of pools tested	5,444	2,687
Number of pools positive	40	51
Number of individual tests required	400	255
Total number of tests required	5,844	2,942
Number of positive tests detected	40	51
Cost per test*	40	40
Cost without sample pooling strategy*	2,177,600	537,400
Cost with sample pooling strategy*	233,760	117,680
Total cost savings (%)	89.26	78.10

**All costs are in US dollars.*

Testing a batch of 94 individual samples per plate in a single run required a total time of 145 minutes. Utilizing the pooling approach, we tested 470 samples per plate (in pools of 5) and 940 samples per plate (in pools of 10) within 175 minutes and 215 minutes, respectively in a single run. Testing 13,435 samples individually would take 203.08 hours. However, with the pool of 5 samples, it took only 61.83 hours, including the testing of deconvoluted pooled positive samples. This represents a 3.28-fold improvement in testing efficiency. Similarly, testing 54,440 samples individually would have required 820.25 hours, but pooling them into 10-sample pools reduced the time to 160.66 hours, resulting in a 5.10-fold improvement in testing efficiency. Therefore, the pooling approach saved 69.55 of the time for a pool of 5 samples and 80.41 for a pool of 10 samples compared to individual testing.

Discussion

During the response to COVID-19 in 2021, the implementation of our sample pooling approach in a laboratory demonstrated significant advantages in enhancing SARS-CoV-2 testing capacity. Furthermore, our approach was simple and time-efficient, and effectively minimized resource consumption, including the use of reagents and testing materials.

We observed a drop in the mean C_t value of 2.0 for 5-sample pools and 3.6 for 10-sample pools. Our findings align with those of a 2020 study by Praharaj et al. that reported C_t value variances of 2.18±1.86 cycles for 5-sample pools and 3.81±2.26 cycles for 10-sample pools. A more recent study in 2022 by Rajamani et al documented C_t differences of 2.6±0.67 cycles for 5-sample pools and 4.3±1.47 cycles for 10-sample pools.[8,9] Similar studies conducted in India, Spain, Japan, and the UAE also reported decreases in C_t values when implementing a pooling strategy.[10–13] In a real-time RT-PCR test that operates with 100% amplification efficiency, one would anticipate an approximate difference of 3.3 C_t in a sample of 10-fold dilution.[14] The disparities in average C_t values observed in our study between individual and pool positive were in line with this expectation.

We observed a slight increase in mean C_t value differences for both pools of 5 and 10 samples when analyzing cases with C_t values >35. A similar study conducted in India highlighted the potential for missing individual positive cases when viral loads are very low.[15] The drop in mean C_t values associated with low viral loads can be attributed to the fact that as the number of negative pooled samples increases, the amplified RNA takes longer to reach the threshold, which could be the expected outcome of sample dilution associated with the principle of the sample dilution effect.[16] Research from Egypt has emphasized that the pooling strategy can affect the test's sensitivity when dealing with samples exhibiting weak viral loads.[16] Consequently, it is crucial to exercise caution when interpreting results from pooled samples. Any subtle indications or minor amplifications in a single gene should prompt individual testing to ensure that positive cases are not overlooked.

Our study demonstrated that employing a sample pooling method can enhance testing efficiency while concurrently reducing the resources required for SARS-CoV-2 testing. A positive rate of 0.13% resulted in savings of 89.26% for pools of 10 and 78.10% for pools of 5 samples. Similar studies have reported the cost-effectiveness of the pooling method.[17–19] Sample pooling strategies also reduced the turnaround time for reporting.[20,21] In our study, the testing efficiency of pools of 10 samples was more effective than pools of 5 samples, with the former increasing testing efficiency by 5.10-fold, and the latter by 3.28-fold. A similar study from India demonstrated that a 5-sample pool was more effective than a 10-sample pool with efficiency increases of 2.15-fold for the 5-sample pool and 1.8-fold for the 10-sample pool.[21] The difference in the effectiveness of the pooling approach could be due to the higher prevalence rate in their setting. Our study demonstrated that implementation of a pooling approach saved 69.55% of the time for a pool of 5 samples and 80.41% for a pool of 10 samples. The implementation of a pooling strategy not only substantially reduced resource consumption but also significantly decreased processing time, allowing for efficient management of the overwhelming demand for testing.

Limitations

A limitation of this study was the lack of generalizability as it was carried out within a single laboratory, confined to a specific geographical region, and focused solely on assessing two distinct pool sizes. Additionally, the lack of published data on the prevalence rate of SARS-CoV-2 infection in the study area during the study period further limited the analysis. Furthermore, the study was conducted in a real-life setting, preventing the determination of sensitivity and specificity for the pooling strategy, as there were no instances of negative pool samples being deconvoluted and retested.

Conclusion

In summary, considering the benefits and drawbacks of adopting the pooling technique, especially in a low-resource environment, pooling samples proved more advantageous and effective. The pooling technique helped expand the testing capacity and addressed the challenges associated with mass testing while also lowering costs, reducing the required workforce, and saving time. However, prior to implementing the pooling strategy, it is essential for all laboratories to perform validation studies specific to their testing kits and extraction/amplification platforms, considering the known COVID-19 prevalence rate.

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Conflicts of Interests

No conflict of interest declared.

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Outbreak Investigation and Response: Two Fatal Cases of Avian Influenza A(H5N1) Detected in Humans in October 2023, Cambodia

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Abstract

In October 2023, Cambodia reported two fatal human cases of influenza A(H5N1) from two provinces. The national and subnational rapid response teams investigated the outbreak to describe its characteristics, identify potential linkages between the cases, assess the outbreak magnitude, understand the local perspective and response. Medical records were reviewed, and contact tracing and active case finding were conducted in the affected areas. Laboratory investigation and environmental survey were performed. Local authorities were interviewed. The two cases, confirmed to have influenza A(H5N1) clade 2.3.2.1c, were a 50-year-old man from Svay Rieng Province and a 2-year-old girl from Prey Veng Province. Both cases had direct contact with sick and dead poultry at their house before developing respiratory symptoms. We identified 65 close contacts and 15 suspected cases who tested negative for influenza A, influenza B and SARS-CoV-2. Inappropriate practices of handling sick and dead poultry and allowing free-roaming backyard poultry within houses were identified in the affected villages. There was no linkage between the two cases and no additional cases were found during the investigation. During the response, there was a lack of awareness about avian influenza among communities and health workers. Appropriate medication (e.g., oseltamivir) should be stockpiled at the district level. A lack of coordination and communication among One Health sector was identified. We recommended promoting a joint multisectoral coordination for investigations, strengthening surveillance systems, increasing avian influenza awareness, allocating resources, and holding daily coordination meetings among stakeholders for effective planning and communication.

Keywords: outbreak investigation, avian influenza, influenza A(H5N1), Cambodia

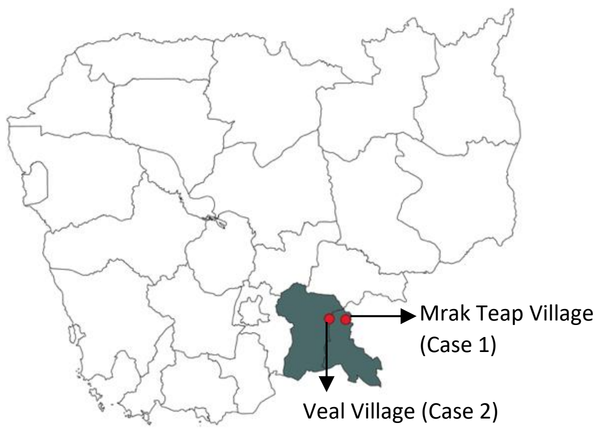
Introduction

Avian influenza A(H5N1) viruses are associated with poultry outbreaks and transmission to humans, with a high case fatality rate (CFR) of 51% globally.[1,2] In 1997, the first human A(H5N1) was associated with infected poultry in Hong Kong.[3] Since 2003, A(H5N1) virus has emerged in East and Southeast Asia.[4–7] Cambodia reported 56 human A(H5N1) cases with a CFR of 66% between 2005 and 2014.[8,9] No human cases of A(H5N1) were reported after 2014 until two cases were detected in February 2023 in Cambodia. In early October 2023, the rapid response team notified the Department of Communicable Disease Control, Ministry of Health (CDC-MoH) of two suspected avian influenza cases. A 50-year-old man from Svay Rieng Province (Case 1) and a 2-year-old girl from Prey Veng Province (Case 2) both tested positive for A(H5N1) virus. The field epidemiologists from the national and subnational levels of the Ministry of Health (MoH) actively investigated from 9 to 23 Oct 2023. The investigation aimed to describe the characteristics of cases, identify potential linkage between the two cases, assess the outbreak magnitude, understand the local perspective and response to the outbreak.

Methods

Outbreak Setting

The investigation was conducted in two affected villages in Svay Rieng and Prey Veng provinces (Figure 1).



Case 1: Mrak Teap Village, Tros Commune, Romeas Haek District, Svay Rieng Province. Mrak Teap Village is approximately five kilometres from the nearest health center, three kilometres from the district referral hospital, and 40 kilometres from Svay Rieng Town.

Case 2: Veal Village, Smaong Khang Tboung Commune, Kamchay Meas District, Prey Veng Province. Veal Village is around five kilometres from the nearest health centre, about 10 kilometres from the district referral hospital, and about 40 kilometres from Prey Veng Town.

In the two affected villages, over 85% of households raise small-scale backyard poultry farming.

Figure 1. Location of avian influenza cases in Cambodia, 2023

Epidemiology Investigation

Medical records of both cases were reviewed by the investigation team using a case investigation form consisting of patient identifier information, clinical information, and signs and symptoms. We interviewed both family members and clinicians to collect information on the patient's medical history and exposures, such as contact with ill or dead poultry.

An active case finding was conducted at 1) the health facilities by reviewing medical records of cases with influenza-like illnesses (ILI) symptoms (i.e., having fever (≥38.0 °C) with either cough or sore throat) in the affected districts from 1 Sep 2023 to 9 Oct 2023, and 2) a community survey was conducted door-to-door in the affected villages. We sought information on individuals with symptoms of ILI or who met the case definition. Those with symptoms were referred for sample collection.

Two A(H5N1) events occurred in two different provinces. A suspected case was a person who lived in Romeas Haek District, Svay Rieng Province between 26 Sep 2023 and 7 Oct 2023, or Kamchay Meas District, Prey Veng Province, between 25 Sep 2023 and 6 Oct 2023 and had a history of unprotected exposure to any infected birds, or to an environment where infected birds or visited live bird markets within seven days before the onset of symptom with a fever or history of fever and at least one of the following symptoms: cough, sore throat, dyspnea, runny nose, difficulty breathing, or headache. A confirmed case was a person who had a nasopharyngeal (NP) and oropharyngeal (OP) swab specimen that tested positive for A(H5N1) by molecular technique. A close contact was a person who had direct (distance less than two meters and duration more than five minutes) and unprotected (no personal protective equipment) contact, in a room or other enclosed space (e.g., vehicle) with a confirmed case between one day before and 14 days after the onset of symptoms of the case.

Laboratory Investigation

All suspected cases had NP and OP swabs tested for influenza A, influenza B and SARS-CoV-2 by reverse transcription-polymerase chain reaction technique. Close contacts and suspected cases were tested for antibodies for A(H5N1) virus.

Environmental Study

Five individuals were interviewed: two village chiefs, one poultry dealer from Mrak Teap Village, and two village animal health volunteers from Mrak Teap Village and Veal Village. Interviews focused on their perspectives on poultry deaths, movement, and feeding practices by using an unstructured questionnaire.

We inspected index houses (observed poultry and their surrounding environment) and households in the villages to determine if there were any ill or dead poultry. A total of 58% (67/116) of households in Mrak Teap Village and 31% (40/130) of households In Veal Village were visited. We used an unstructured questionnaire to interview households in the affected villages about ill or dead poultry.

Data Analysis

Descriptive analysis was conducted by calculating the median (1^{st} quartile (Q1), 3^{rd} quartile (Q3)) values for the age of close contacts and suspected cases, treated as continuous data. Frequencies and percentages were calculated for categorical variables. Data analysis was performed using Microsoft Excel version 14. Households in villages with ill or dead poultry were mapped using QGIS software version 3.28. Qualitative data analysis was used to examine key informants' ideas and opinions, which were transformed into themes and then categorised based on different elements of the responses.

Ethics

The outbreak is a part of the public health emergency response conducted by the Cambodia Ministry of Health. The data collected went through a process of anonymization, guaranteeing that the authors had no access to any identifiable information.

Results

Description of the Two Confirmed A(H5N1) Cases

Case 1

A 50-year-old male with diabetes (reported by his son) living in Mrak Teap Village (Figure 1). The village is located in a rural area that shares a border with Vietnam. Most residents were farmers with raised small-scale poultry free-roaming in their backyards. The case prepared an ill chicken a few days before symptoms onset. On 2 October, patients developed fever, vomiting, and trembling. He was self-treated with 500 mg of paracetamol and 500 mL of intravenous fluid. On 4 October, he visited a private clinic and was referred to the district referral hospital because symptoms did not improve. The referral hospital physician referred the patient to the national hospital in Phnom Penh. The family opted for a private clinic in Vietnam, which is closer to their home. The patient was admitted to the clinic in Vietnam and diagnosed with severe pneumonia from 5–6 October. The patient's vital signs included blood pressure of 175/100 mmHg, pulse of 130 beats per minute, respiratory rate of 28 breaths per minute, SpO_2 of 92%, and body temperature of 37.7 °C. On 7 October, his condition worsened, and he was referred to Calmette Hospital in Phnom Penh, where he died. Tests on 8 October confirmed A(H5N1) virus clade 2.3.2.1c.

Case 2

A 2-year-old girl who did not have underlying disease and lived with her grandmother at Veal Village (Figure 1). Most of the people were farmers and had free-roaming poultry around their homes. The girl played in the yard. The grandmother reported that their chickens died off every day for a week before the girl's onset of symptoms. Ill chickens that died were buried behind the house, while the ill or dead adult chickens in good condition were prepared for meals. However, ill or dead chickens in the villages were not reported to the local authorities. On 1 October, the girl developed a fever and vomiting and was treated at home by a local nurse. The patient's symptoms did not improve. The girl was transferred to a private clinic in the district. On 3 October, the girl developed coughing and difficulty breathing. On 4 October, despite the girl's deteriorating condition, her family was relocated to the National Pediatric Hospital in Phnom Penh on 5 October. On 6 October, NP and OP swab samples were sent to the NIPH laboratory and tested positive for A(H5N1) virus clade 2.3.2.1c on 9 October. The patient died with a diagnosis of septic shock and severe bronchopneumonia.

Active Case Finding and Contacts from Svay Rieng and Prey Veng Provinces

In Svay Rieng Province, the active case finding identified 51 individuals (44 close contacts and 7 suspected cases), of which 38 (70%) were male. The median age was 34 years (Q1=26, Q3=51). Most (84%) were aged ≥15 years. Twenty-two (43%) were reported as farmers. In Prey Veng Province, there were 21 close contacts. Out of 29 individuals, 15 (52%) were male; the median age was 26 years (Q1=14, Q3=39), and 21 (72%) were aged ≥15 years. Almost half were farmers (Table 1).

Table 1. Characteristics of the close contacts and suspected cases from the avian influenza events in Cambodia, 2023

Characteristics	Svay Rieng Province (n=51)		Prey Veng Province (n=29)	
	No.	%	No.	%
Gender				
Male	38	75	14	48
Female	13	25	15	52
Age in years				
Median in years (Q1–Q3)	34 (26–51)		26 (14–39)	
≤6	3	6	4	14
7–14	5	10	4	14
15–40	23	45	14	48
>40	20	39	7	24

Table 1. Characteristics of the close contacts and suspected cases from the avian influenza events in Cambodia, 2023 (cont.)

Characteristics	Svay Rieng Province (n=51)		Prey Veng Province (n=29)	
	No.	%	No.	%
Occupations				
Farmers	22	43	13	45
Healthcare providers	9	18	5	17
Students	7	14	8	28
Ivory priest	5	10	-	
Childs	3	6	3	10
Driver	2	4	-	
Animal/health volunteer	2	4	-	
Government staff	1	2	-	
Types				
Suspected cases	7	14	8	28
Close contacts	44	86	21	72
Laboratory results for SARS-CoV-2 and A(H5N1)				
PCR tests negatives	51	100	29	100
Serology testing for A(H5N1)				
Tested negative for acute serum (n=59)	44	100	15	100
Tested negative for convalescent serum after 21 days (n=48)	37	100	11	100

Laboratory Detection for Close Contacts and Suspected Cases

A total of 15 suspected cases (7 from Svay Rieng Province and 8 from Prey Veng Province) had symptoms, including fever (100%), coughing (87%), runny nose (47%), and sore throat (27%). Laboratory test results for all 15 cases showed absence of SARS-CoV-2 and influenza A and B. Regarding the antibodies of A(H5N1), a total of 59 acute serum and 48 convalescent serum samples were collected and tested negative antibodies (Table 1).

Environmental Study

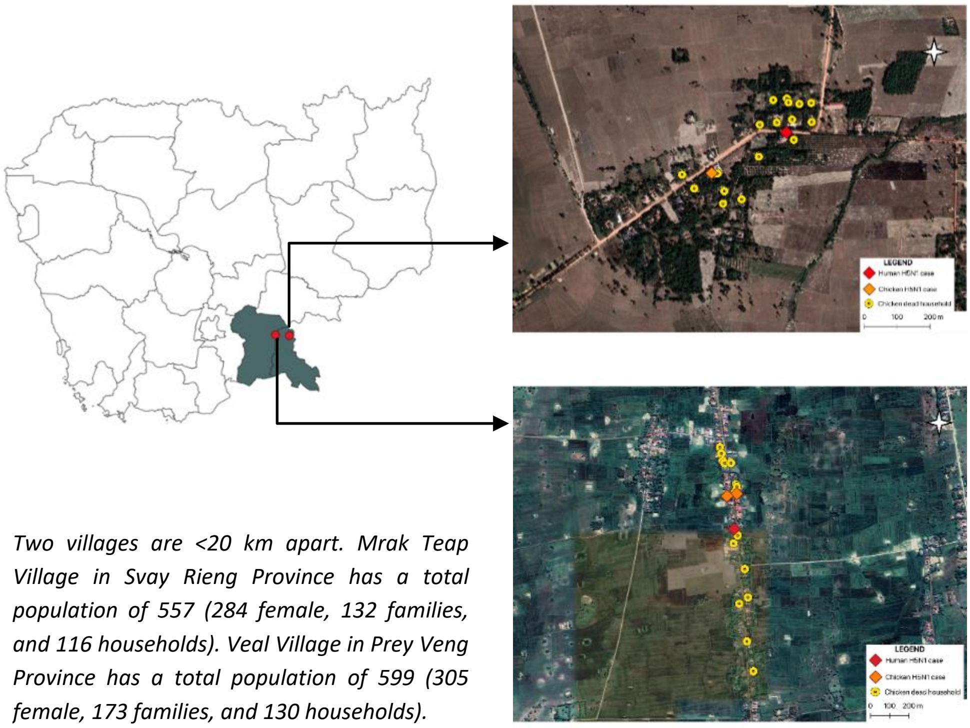
Animal health volunteers living in the villages have unspecified roles; however, they assist the community by supporting animal husbandry, particularly by providing basic care to families with ill or dead poultry when needed. The animal health volunteers from Mrak Teap and Veal villages reported that poultry deaths occurred in early September 2023, including at the house of cases 1 and 2. This pattern of poultry death spread from one household to another in their village. The villagers were unaware of avian flu. They cooked and consumed the ill or dead chickens for daily meals and even shared them with neighbouring households. An animal health volunteer reported his chickens tested positive for A(H5N1) virus during the outbreak. He stated that the villagers reported, "Poultry deaths occurred every year, and people typically prepared them as daily meals instead of buying food from the market". The villagers became aware of eating ill or dead chickens after the death of Case 1.

Most households in the affected villages who had dead poultry reported that poultry started dying in early September 2023 until cases were detected. The ill or dead chickens were cooked for meals. As noted by the villagers, "Every year chicken died, and people usually cooked them for meals". If the poultry died overnight, the household in the village typically buried it, as they considered it poor-quality meat. However, if the bird was ill or had recently died, the majority were cooked for food.

According to the poultry dealer in Svay Rieng Province, the dealer bought chickens from the village and surrounding areas and sold them to market in Phnom Penh. He emphasized that all the chickens were healthy and had never been removed from their cages. He reported, similarly to other responders, that chicken deaths were a normal occurrence, which happened every year, and that ill or dead chickens in good condition were often prepared for meals.

Village chiefs from Mrak Teap and Veal villages reported that most villagers had moved to other provinces for work, and only children and the elderly resided in the villages. A villager reported that poultry had died in early September 2023. These poultry were raised as free-roaming chickens in the backyards of households. The poultry dealer comes from Romeas Haek District in Svay Rieng Province, although the exact village of origin of the chickens was uncertain. A lack of awareness among local authorities and the community regarding A(H5N1) virus transmission between poultry and humans was evident. Poor practices in the community related to the handling of ill or dead poultry were identified. From our investigation, there was no epidemiological linkage between Case 1 and Case 2. There was uncertain information about the poultry transmission chain between both affected villages.

We conducted direct observation in Mrak Teap and Veal villages from 9–10 Oct 2024. In Mrak Teap Village, 19 (28%) of 67 households reported ill or dead poultry. Villagers in this area allowed their poultry to roam freely for feeding. Similarly, in Veal Village, 18 (45%) of 40 households reported ill or dead poultry, with free-roaming feeding practices observed (Figure 2).



Map 1: 19 out of 67 households reported poultry die-offs in Mrak Teap Village in the Tros Commune, Romeas Haek District, Svay Rieng Province.

Map 2: 18 out of 40 households reported poultry die-offs in Veal Village, Smaong Khang Tboung Commune, Kamchay Meas District, Prey Veng Province.

Two villages are <20 km apart. Mrak Teap Village in Svay Rieng Province has a total population of 557 (284 female, 132 families, and 116 households). Veal Village in Prey Veng Province has a total population of 599 (305 female, 173 families, and 130 households).

Figure 2. Geographical distribution of the two avian influenza cases in Cambodia, 2023

Action Taken for Control Measures and Case Management

The active case finding identified 15 suspected cases with ILI symptoms during the follow-up period in both villages; however, none of the samples tested positive for pathogen (Table 1). Patients with mild ILI symptoms who did not meet the case definition were recommended for home quarantine and provided basic care and/or treatment with oseltamivir. We conducted active surveillance to find additional cases at health facilities and in the community. We set up a mobile health post in both affected villages, starting from the first detected case, and if new confirmed cases were identified, we began a new 14-day follow-up following the case definition. If a person met the case definition, a specimen was collected at the health facility level and sent to a laboratory for testing. Awareness about A(H5N1) infections, including the risk of transmission and signs and symptoms, was raised among healthcare workers and the community during the response.

Discussion

Two fatal cases were confirmed positive for A(H5N1) virus with clade 2.3.2.1c; a 50-year-old man and a 2-year-old girl. Two cases had direct contact with ill or dead poultry a few days before the start of symptoms. Both cases were primarily treated by local nurses, resulting in delayed admission to the hospital. A high CFR is associated with delayed hospital admissions.[10] There was a lack of oseltamivir stock at the district level for response during the investigation. The A(H5N1) virus has been sporadic in humans in Cambodia since 2005.[11] There was no epidemiological linkage between the two cases evidenced from the investigation. In both households, there were poultry die-offs in their village, and cases had direct contact with ill or dead chickens in their respective houses. Delayed treatment in both cases may have played an important role in the outcome. Early treatment with oseltamivir is advised, as starting it more than 48 hours after symptoms appear can lead to poorer outcomes.[12,13] The 50-year-old man died seven days after his onset date. This indicates he was diagnosed and admitted late, leading to delays in receiving proper treatment at the hospital. The 2-year-old girl died nine days after the onset. It might be appropriate treatment was not given during the onset period, and there was a delay in diagnosis and admission. A reported in Indonesia, delays in providing proper care to human cases of A(H5N1) are associated with delays in diagnosis.[14] Case 1 butchered dead chickens a few days before symptoms onset. Case 2 had a history of exposure to ill or dead chickens at her house, and chickens were also cooked for meals, similar to Case 1, but it is uncertain whether the girl consumed the chicken meat. Both cases had direct contact with dead chickens, similar to two cases with confirmed A(H5N1) in the Prey Veng in February 2023.[15] All specimens collected from close contacts and suspected cases living in the affected villages tested negative for influenza A and B and SARS-CoV-2. In 2005, Thailand reported 12 people died from A(H5N1) infection; two of the deaths had no direct contact with birds, indicating they may have contracted the virus from another person while transmission between poultry to humans.[16,17] In rural Cambodia, people raise small-scale backyard poultry farms where chickens forage for their own feed or are provided with grains of rice once or twice a day. Our study reveals that in both affected villages, the human cases of A(H5N1) infection were linked to ill or dead birds carrying the virus or environments contaminated with A(H5N1) virus as evidenced by samples from ill poultry with A(H5N1) viruses detected. Since 2005, cases of human infection due to poultry-to-human transmission have been sporadically reported in Cambodia. A study among women showed that half lacked sufficient knowledge and failed to follow the right practices for dealing with the high-pathogenic avian influenza virus.[18] Another study in Vietnam compared a group at high environmental risk for A(H5N1) with a non-exposed group, revealing that less than 40% of participants did not seek medical attention either due to flu-like symptoms or out of fear.[19] However, there was a lack of information regarding the movement of poultry in the villages, particularly concerning ill or dead poultry. The report from the local key informants highlights uncertain information about the reasons behind chicken ill and deaths in the villages.

Limitations

Several limitations were identified during the investigation. There was a lack of manpower to respond to the outbreak at the national level due to two overlapping events that occurred over the weekend. Additionally, there was no information available regarding poultry movement or exchange from Vietnam, which borders the affected provinces. There was also a lack of information on wild bird movement and its potential relationship with domestic birds, making it difficult to identify the source of A(H5N1) virus infection in the villages.

Conclusion

Two fatalities have been confirmed as a result of A(H5N1) infection, with the 2.3.2.1c. Both cases presented with severe pneumonia and had delayed treatment. Both cases were exposed to ill or dead chickens at their homes at the same time in late September. No epidemiological linkage between the two cases and no secondary cases were identified. We identified a lack of A(H5N1) awareness in the two communities for both human and animal health practices. Control measures included active case detection, enhanced surveillance, and medical management of persons with ILI were implemented.

Recommendations

Our findings suggest that joint multisectoral collaboration, with coordination and communication among human, animal and environmental health sectors using the One Health approach, is necessary for responding to H5N1 outbreaks. Furthermore, we recommend conducting daily coordination meetings among stakeholders during investigations to facilitate planning, coordination, and the exchange of information. Strengthening the surveillance system at both health facilities and community levels is crucial to capture any unusual events which trigger an early response to the H5N1 outbreak in the country. The MoH should allocate resources for antiviral medication and antiviral oseltamivir and ensure its availability at the provincial level. Additionally, risk communication and community engagement can play an important role in preventing further bird flu outbreaks by increasing awareness of the A(H5N1) virus among healthcare professionals and the community.

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Conflicts of Interests

The authors declare that there is no conflict of interest.

Suggested Citation

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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).

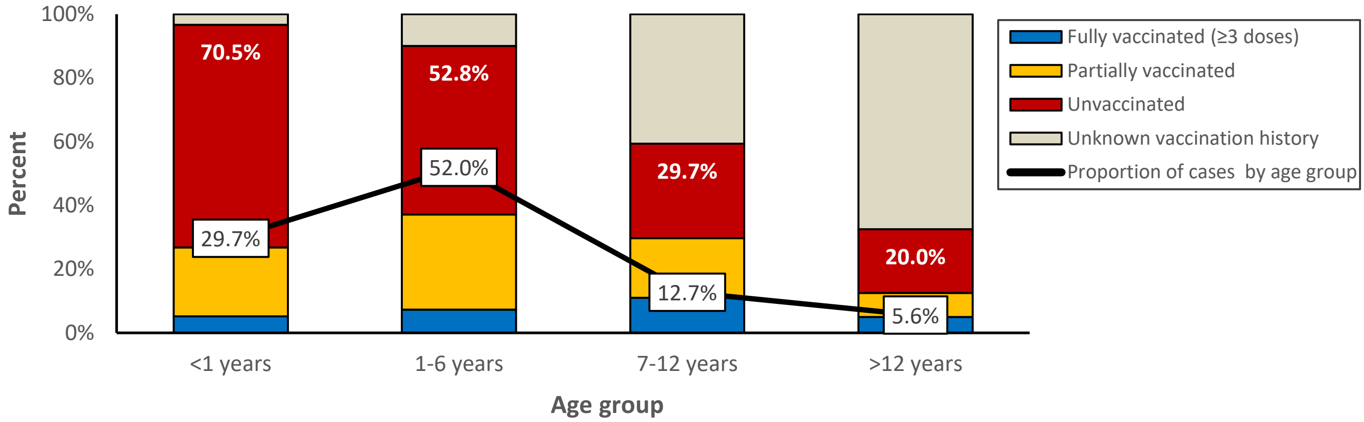
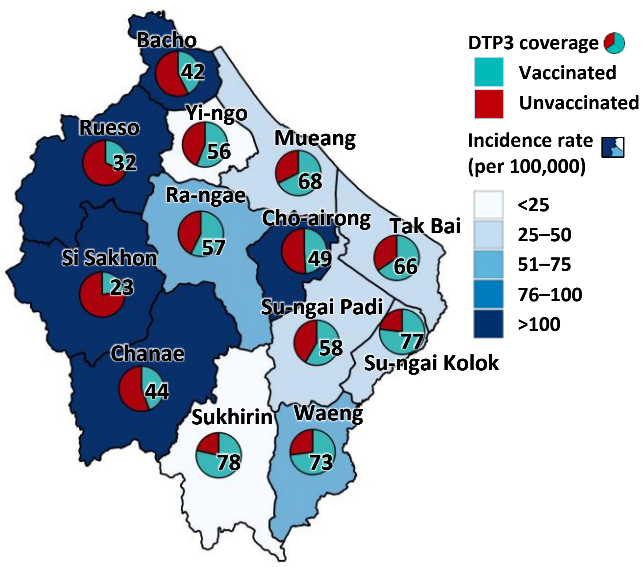


Figure 1. Percentage of cases by diphtheria-tetanus-pertussis vaccine status and age group during the pertussis outbreak from September 2023 to May 2024, Narathiwat Province, Thailand

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

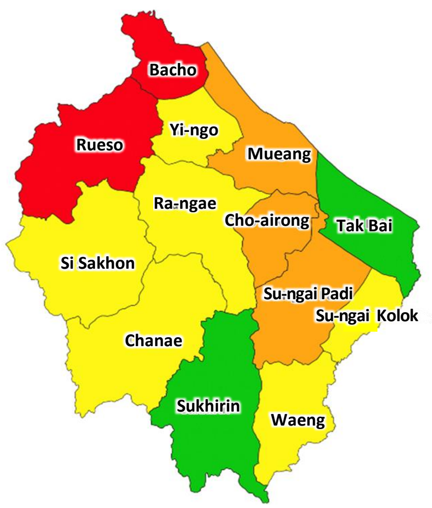


Figure 3. Risk assessment matrix correlating pertussis case numbers with baseline diphtheria-tetanus-pertussis vaccine coverage by district, showing risk levels with color-coded categories used by the Narathiwat EOC during the pertussis response

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

Risk level / Operations	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).

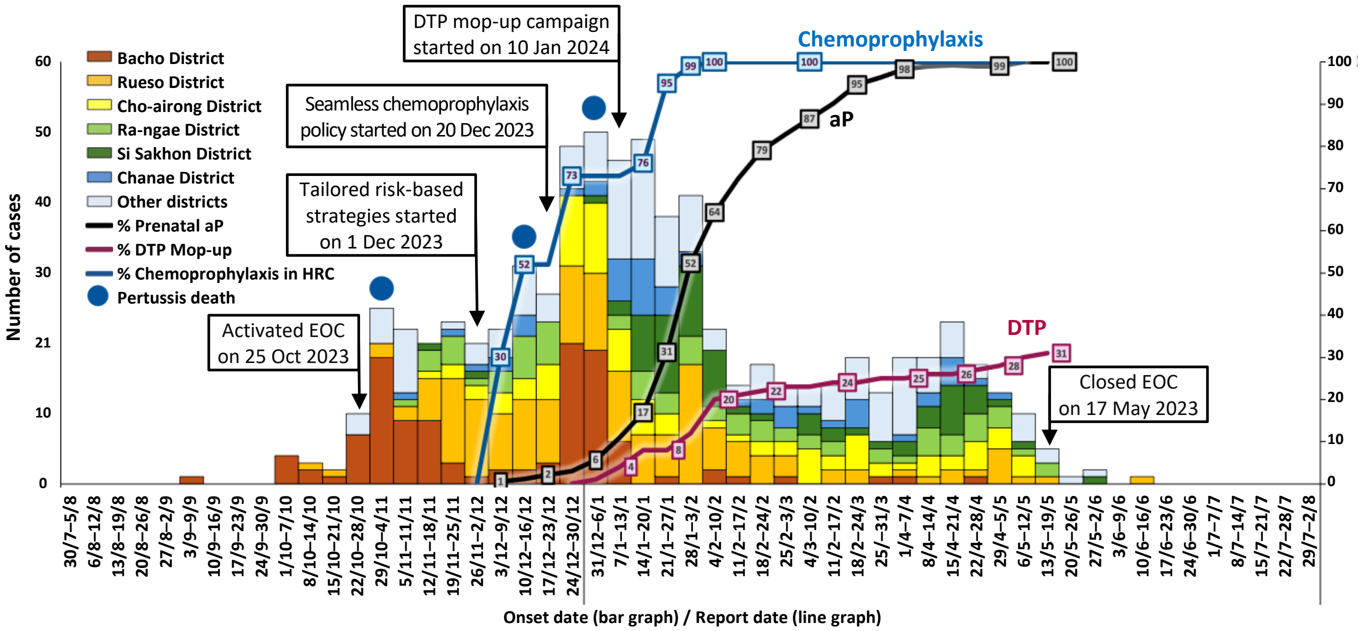


Figure 5. Number of pertussis cases by onset date (seven-day counts) and implemented control measures, e.g., chemoprophylaxis in high-risk close contacts (HRCs), prenatal acellular pertussis (aP), and diphtheria-tetanus-pertussis (DTP) vaccine mop-up, by Narathiwat Emergency Operations Center (EOC) during 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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The Patterns and Associations between Attitudes towards Active Travel and Physical Activity among Residents in Three Selected Provinces of Thailand

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Abstract

Active travel offers opportunities for regular physical activity, influenced by socio-demographic, socio-economic, and socio-psychological determinants. This study investigated the associations between positive attitudes towards active travel environments and literacy with sufficient physical activity in Thailand. A cross-sectional study was conducted with 343 residents recruited from three communities in 2019. A self-administered questionnaire collected data on demographics, physical activity levels (using the Global Physical Activity Questionnaire), and attitudes towards 11 supportive conditions for active travel. Factor analysis identified three factors: (1) attitudes towards public transport environments, capturing perceptions of convenience, attractiveness, and affordability; (2) attitudes towards walking and cycling environments, reflecting supportive conditions like safety and conduciveness; and (3) active travel literacy, relating to awareness and understanding of active travel concepts. Multivariable logistic regression analysis revealed that participants with positive attitudes towards public transport environments (adjusted odds ratio (AOR) 2.06, 95% confidence interval (CI) 1.01–4.17) and active travel literacy (AOR 2.93, 95% CI 1.10–7.79) had a significantly higher likelihood of achieving sufficient physical activity. Policymakers should prioritize enhancing the convenience, attractiveness, and affordability of public transport and promote educational campaigns to boost active travel literacy and encourage active travel behaviors.

Keywords: physical activity, active travel, prevalence, associated factor, Thailand

Introduction

The health benefits of sufficient physical activity in reducing risks of non-communicable diseases have been well documented.[1] Insufficient physical activity is responsible for 7.2% of all-cause deaths worldwide.[2] Middle-income countries have the highest total number of such deaths due to their larger populations.[2] Thailand, an upper-middle-income country in Southeast Asia, has been experiencing a gradual decline in sufficient physical activity rates.[3–7] Adults with sufficient physical activity declined from 81.5% in 2009 to 80.8% in 2015.[3,4] In response, the Thai government launched the National Physical Activity Strategy 2018–2030, alongside various initiatives to promote physical activity across cities.[8,9]

One effective way to combat insufficient physical activity is through active travel, which includes walking or cycling solely for transport or in combination with public transport. Recent studies have extensively reported the linkage between the health benefits of physical activity and active travel.[10–12] Active travel provides opportunities for regular physical activity as it consumes less time, and is convenient to integrate as a form of exercise.[13] In Thailand, previous surveys have shown that active travel contributed to 15% and 17% of daily energy expenditure from physical activity.[14,15]

Understanding the factors that influence active travel is crucial for developing effective interventions. According to the conceptual frameworks of active travel, socio-demographic, socio-economic, and socio-psychological determinants influence active travel.[13,16–18] The social context of active travel is conceptualized through a multi-layered approach composed of community, peers, household, and the individual. Objective individual characteristics, the accessibility of destinations, and the availability of mobility tools are interpreted through subjective perceptions of mobility options. These, together with socio-psychological variables, shape people's intention to choose specific travel activities and, ultimately, the behavior itself.[13,16–18] However, in Thailand, the specific role of positive attitudes towards active travel environments and literacy in influencing sufficient physical activity levels has not been thoroughly explored.

The Thai Walking and Cycling Institute plays a strong role in promoting active travel nationwide.[19] One of the Institute's most remarkable initiatives is the promotion of walking and the use of bicycles in ten communities across five regions of the country.[19] A study in Thailand suggested that the initiative helped promote physical activity in the communities and contributed to the decline in energy expenditure and carbon dioxide emissions among the locals.[20] However, while the initiative has shown promise, there is a significant gap in understanding the relationship between sufficient physical activity levels and individual attitudes towards supportive conditions for active travel.

This study used a case study approach in three selected communities to identify the prevalence and associations between sufficient physical activity levels and individual attitudes towards conditions that support active travel.

Materials and Methods

Study Design, Population, and Sample Size

A cross-sectional study was employed, recruiting residents from three of ten communities in the Thai Walking and Cycling Institute's project in 2019, aiming for geographical diversity and a broad range of socio-demographic, socio-economic, and environmental contexts.[19]

The selected communities included King Taksin in Bangkhla District, Chachoengsao Province, Central Region (Community A); Suk Sabaijai in Mueang Kalasin District, Kalasin Province, Northeastern Region (Community B); and Ban Thatsobvan in Chiang Kham District, Payao Province, Northern Region (Community C). Key features of the three communities are exhibited in Table 1.

We used the sample size formula for estimating prevalence of sufficient physical activity levels.[21] The formula used was as follows:

$$n = \frac{Z^2 \, x \, P(1-P)}{d^2}$$

where Z = 1.96 (the Z value for 95% confidence level)

P = 0.62 (expected proportion based on national prevalence of sufficient physical activity level from the 2016 National Physical Activity Survey)[22]

d = 0.06 (accepted margin of error)

Based on this formula, the calculated sample size was 252. Adjusting for a 10% non-response rate, the target sample size was increased to 280. Ultimately, 343 samples were collected, exceeding the required minimum. Data from the three communities were combined, as they shared key characteristics outlined in Table 1, making them comparable for analysis.

Table 1. Key features of the three selected communities

Feature	Community A (King Taksin)	Community B (Suk Sabaijai)	Community C (Ban Thatsobvan)
Region	Central	Northeastern	Northern
Village size (square kilometers)	0.5	1.5	0.5
Population density (persons/square kilometers)	900	384	1,808
Topography	Plain	Plain	Plain
Land use	Accommodation zone	Accommodation zone	Accommodation zone
Roads and intersections	1–2 lanes, intersections every 50–100 meters	1–2 lanes, intersections every 50–100 meters, bypass	1–2 lanes, intersections every 50–100 meters
Vehicle speed (kilometers/hour)	20–40	40–70	20–40
Active mobility infrastructure	Functional sidewalks, bike lanes	Functional sidewalks, bike lanes	Narrow sidewalks, no bike lanes, optimal lighting

Questionnaire Design and Data Collection

A self-administered questionnaire was utilized to assess physical activity levels. Adapted from the World Health Organization Global Physical Activity Questionnaire, the questionnaire comprised three main parts: demographic profiles, physical activity levels, and self-assessment of attitudes towards supportive conditions for active travel in communities.[23]

The first part collected demographic information including gender, age, body mass index (BMI), education level, occupation, and monthly income. The second part focused on physical activity across five sections: vigorous intensity at work, moderate intensity at work, moderate intensity in transport, vigorous intensity in recreational activities, and moderate intensity in recreational activities. Each section included three questions: whether any physical activity was done last week, the number of days physical activity was done, and the number of minutes per day.

The third part assessed respondents' attitudes towards supportive conditions for active travel in their communities. Eleven conditions related to active travel, such as an understanding of active travel, exposure to campaigns, perceived safety, behavior in the community, conducive environments for walking and cycling, convenience and attractiveness of public transport, reasonable pricing, traffic conditions, and sufficiency of recreation areas and communal amenities, were self-rated on a Likert scale (1=strongly disagree to 5=strongly agree).[13,16–18]

Participants were selected by community leaders in consultation with researchers. Questionnaires were distributed by geographical areas, targeting residents aged six years and above in the selected households, but those with reading difficulties were excluded. The questionnaire took approximately 15 minutes to complete. No incentives were provided. Personal data were encrypted for confidentiality, and data were collected from December 2019 to March 2020.

Variable Management and Data Analysis

The dependent variable was sufficient physical activity levels, defined as at least 150 minutes of moderate- or 75 minutes of vigorous-intensity physical activity per week (WHO recommendations).[24] Physical activity levels were determined using responses to the three sections: 1) participants who answered 'yes' or 'no' to the first question about doing physical activity were classified as '1' or '0', respectively, 2) the number of days reported in the second question was divided by seven to convert to a weekly unit. For example, an answer of five days was calculated as 5/7, and 3) activity intensity was classified by metabolic equivalent task (MET) values, with '4' for moderate and '8' for vigorous intensity, with one MET equal to the resting state.[23]

Independent variables included gender, age, BMI, education level, occupation, income range, and factors from factor analysis (explained later). Age was categorized into 8–52 years and 53–85 years (median age of 53 years). BMI was grouped into underweight/normal (BMI <23 kg/m^2) and overweight/obese (BMI ≥23 kg/m^2).[25] Education level was categorized as up to primary education or secondary education and above. Occupation included agricultural workers, office-based employees/business owners, and retired/unemployed. Monthly income was divided into 0–12,000 Thai baht (THB) (US$ 0–348) and 12,001–85,000 THB (US$ >348–2,465) (median income of 12,000 THB (US$ 348), with 1 THB=US$ 0.029 as of 16 Dec 2024).

Attitudes towards support for active travel were assessed using a self-rated Likert scale, grouped into low scores (1–2) and high scores (3–5). Exploratory Factor Analysis reduced 11 questions into composite factors for easier interpretation. Bartlett's sphericity test confirmed data suitability. The 11 questions were grouped using the principal component factor technique, retaining latent factors with an eigenvalue equal to or greater than one.[26] Varimax rotation grouped similar conditions based on the factor-loading matrix, and factor scores were generated using Bartlett's formula. The mean score of the new composite factors was approximately zero, with scores classified into two sub-categories (≥0 and <0). Scores above zero indicated a greater degree of positive attitudes towards active travel support, while scores below zero indicated relatively negative attitudes.

The analysis involved five steps: 1) descriptive statistics for demographic data and self-rated attitudes, 2) chi-square and rank sum tests to explore differences in sufficient and insufficient physical activity across demographics, 3) chi-square test to examine the relationship between attitudes towards a supportive environment for promoting physical activities and physical activity levels, 4) factor analysis to create a composite index reflecting attitudes towards a supportive environment, and 5) multivariable logistic regression to analyze the impact of demographics and composite scores on sufficient physical activity, adjusting for confounders. Robust standard errors accounted for within-province correlations, with statistical significance set at <0.05. All analyses were conducted using STATA software version 14 (StataCorp, College Station, TX, USA, serial number 10699393).

Ethics

The study followed the Declaration of Helsinki guideline and was approved by the Institutional Review Board of the Institute for Development of Human Research Protection in Thailand (protocol code IHRP2019115, No.110-2562, 23 Dec 2019). All participants were fully informed about the study and provided written informed consent.

Results

Baseline Characteristics

A total of 340 samples were recruited; 63% of participants were female (Table 2). Most had a BMI classified as underweight or normal weight (59%) and achieved secondary education or higher (78%). The largest occupation category was office-based employees or business owners (58%). Overall, 74% of participants met sufficient physical activity levels. Older participants (84% versus 61%, $p < 0.05$), those who were overweight or obese (82% versus 66%, $p < 0.05$), and participants with primary education or less (83% versus 69%, $p < 0.05$) showed higher rates of sufficient physical activity than their counterparts.

Table 2. Comparison of sufficient physical activity levels by personal attributes

Characteristics	Overall (%)	Sufficient physical activity (%)	*P*-value*
Gender (n=339)			>0.05
Male	125 (37)	95 (76)	
Female	214 (63)	151 (71)	
Age (n=340)			<0.05
Median (p25, p75)	53 (42, 63)	57 (47, 64)	
8-52 years	163 (48)	99 (61)	
53-85 years	177 (52)	148 (84)	
Body mass index (n=338)			<0.05
Underweight or normal	199 (59)	132 (66)	
Overweight or obese	139 (41)	114 (82)	
Education level (n=319)			<0.05
Up to primary education	70 (22)	58 (83)	
Secondary education or above	249 (78)	171 (69)	
Occupation (n=315)			>0.05
Agricultural workers	36 (12)	25 (69)	
Office-based employees or business owners	184 (58)	133 (72)	
Retired or unemployed	95 (30)	79 (83)	
Monthly income (THB†, n=310)			>0.05
Median (p25, p75)	12,000 (5,000, 20,000)	12,000 (4,000, 24,000)	
0–12,000 THB (US$ 0–348)	170 (55)	118 (69)	
12,001–85,00 THB (US$ >348–2,465)	140 (45)	106 (76)	
Total	340 (100)	250 (74)	

**P-value from chi-square test. †1 Thai baht (THB) equals 0.029 US$ (as of 16 Dec 2024).*

Attitudes Towards Active Travel

Figure 1 showed the average scores of respondents' attitudes towards 11 active travel-supportive conditions in their communities. The highest mean scores were for traffic-free transport (3.8), conducive environments for walking (3.5), and conducive environments for cycling (3.4). In contrast, the lowest scores were observed for the attractiveness of public transport (1.8), the reasonable price of public transport (1.8), and the safety of public transport (1.8).

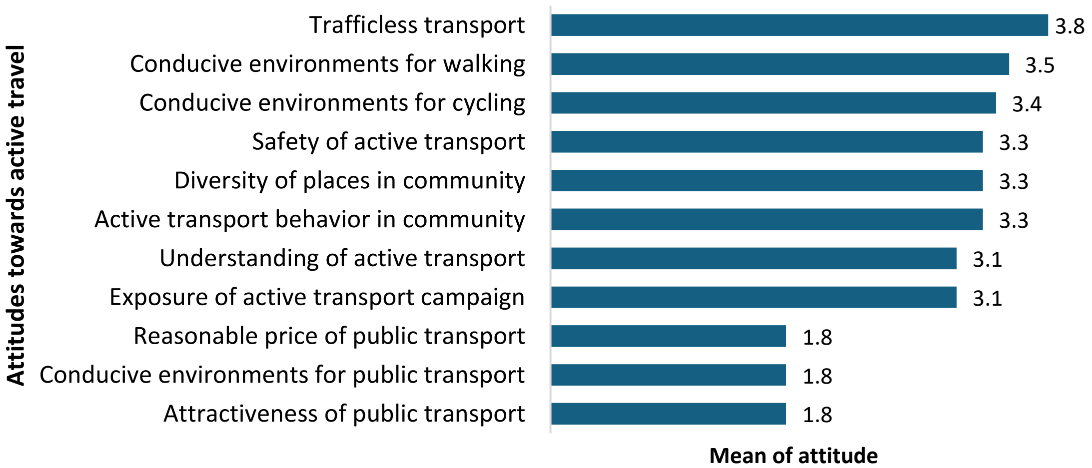
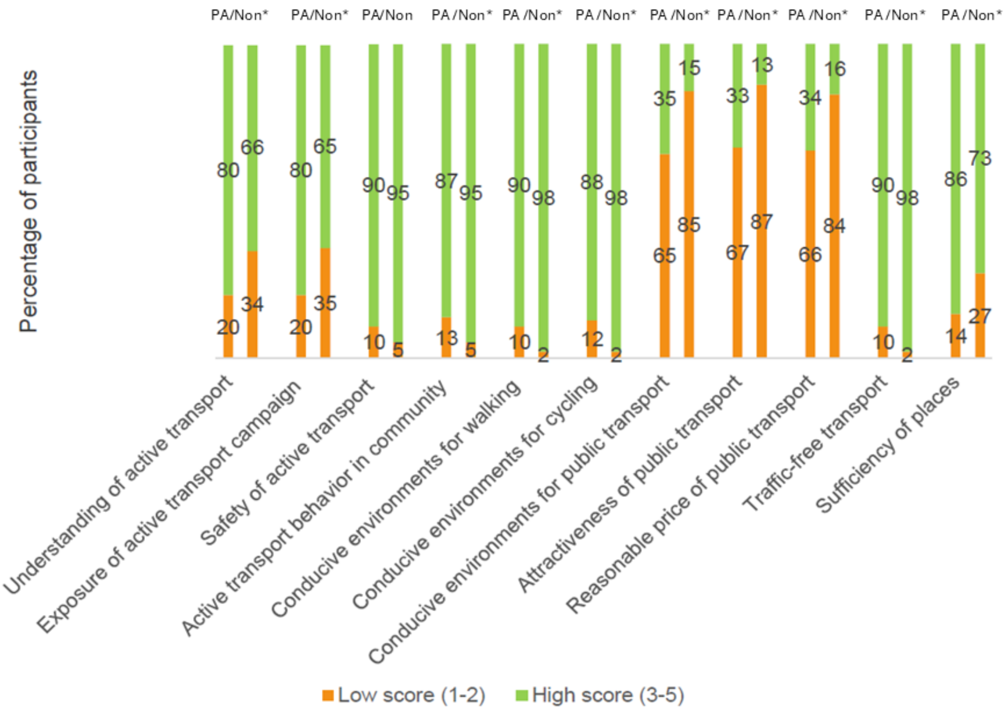


Figure 1. Average scores of attitudes towards active travel conditions

Figure 2 displayed the percentages of participants with sufficient and insufficient physical activity according to different supportive conditions by levels of scores of attitudes towards 11 active travel-supportive conditions in their communities. Participants with sufficient physical activity significantly outnumbered those with insufficient physical activity for high scores in several conditions: understanding of active travel, exposure to the active travel campaign, conducive environments for public transport, attractiveness of public transport, reasonable price of public transport, and sufficiency of places.



**P-value from chi-square test <0.05. PA: sufficient physical activity level. Non: insufficient physical activity level.*

Figure 2. Physical activity levels by attitude scores towards active travel conditions

Exploratory Factor Analysis

Exploratory Factor Analysis of the 11 questions on active transport-supportive conditions identified three primary factors with eigenvalues greater than one: (1) attitudes towards public transport environments (conducive environments for public transport, attractiveness of public transport, and reasonable price of public transport), (2) attitudes toward walking and cycling environments (safety of active travel, active travel behavior in the community, conducive environments for walking, conducive environments for cycling, and sufficiency of recreation areas and communal amenities in the community), and (3) active travel literacy (understanding of active travel, and exposure to active travel campaign) (Table 3). The factor loadings of each question indicate its alignment with one of these themes.

Table 3. Factor loading matrix of the list of attitudes towards the supportive environment for active travel

Variable	Factor 1	Factor 2	Factor 3	Uniqueness
Understanding of active travel	0.15	0.09	**0.73**	0.43
Exposure to active travel campaign	-0.03	0.18	**0.67**	0.51
Safety of active travel	0.03	**0.56**	0.35	0.53
Active travel behavior in the community	0.05	**0.65**	0.08	0.51
Conducive environments for walking	-0.06	**0.77**	0.07	0.39
Conducive environments for cycling	-0.08	**0.84**	0.09	0.27
Conducive environments for public transport	**0.90**	-0.03	0.05	0.17
The attractiveness of public transport	**0.94**	-0.04	0.04	0.12
Reasonable price of public transport	**0.92**	0.00	0.01	0.15
Traffic-free transport	-0.33	0.10	-0.02	0.74
Sufficiency of recreation areas and communal amenities in the community	0.11	**0.33**	0.31	0.71

**Factor loadings in bold indicate variables most strongly associated with each factor. Factor 1 captures attitudes toward public transport environments, Factor 2 reflects supportive conditions for walking and cycling, and Factor 3 relates to active travel literacy.*

Factor Score and Physical Activity Level: Multivariable Logistic Regression Analysis

Multivariable logistic regression analysis revealed that older participants and those with higher BMI had significantly greater odds of having sufficient physical activity levels (adjusted odds ratio (AOR) 1.73, 95% confidence interval (CI) 1.45–2.06, and odds ratio 2.28, 95% CI 1.18–4.41, respectively), as shown in Table 4. Additionally, participants with positive factor scores for attitude towards public transport environments (AOR 2.06, 95% CI 1.01–4.17) and active travel literacy (AOR 2.93, 95% CI 1.10–7.79) were more likely to have sufficient physical activity (Table 4).

Table 4. Multivariable logistic analysis of factors associated with sufficient physical activity levels

Variables	Sufficient physical activity	
	Adjusted odds ratio	95% confidence interval
Age group		
53–85 years (reference=8–52 years)	1.73	1.45–2.06
BMI group		
Overweight and obese (reference=underweight and normal)	2.28	1.18–4.41
Factor of attitude towards public transport environments		
≥0 (reference <0)	2.06	1.01–4.17
Factor of attitude towards walking and cycling environments		
≥0 (reference <0)	1.16	0.47–2.88
Factor of attitude towards active travel literacy		
≥0 (reference <0)	2.93	1.10–7.79

The model adjusted for gender, education, occupation, and income. Only statistically significant variables (p-value <0.05) are shown in the table.

Discussion

This study examined the association between positive attitudes towards active travel environments and literacy with the likelihood of engaging in sufficient physical activity. Notably, positive attitudes towards public transport environments and active travel literacy were significantly associated with a higher likelihood of engaging in sufficient physical activity.

The percentage of participants who achieved a sufficient physical activity level (73%) in these three communities was notably high compared to the estimated national level of 71% for 2019.[22] These high levels of sufficient physical activity could imply positive outcomes from active travel and physical activity promotion initiatives in the communities. However, the involvement of community leaders in the selection process might have introduced elements of convenience sampling, potentially leading to selection and information bias and an overestimation of physical activity levels.

Older age and higher BMI were strongly associated with adequate physical activity, contrary to previous national physical activity surveys. Although, these sub-populations might have difficulties from co-morbidities of obesity and non-communicable diseases to stay active, it was possible that they might have good health literacy about exercise and its benefits in reducing consequences of chronic diseases.[14,15,27,28] In addition, living in communities promoting active transport might create positive attitude towards walking and cycling.[28,29] Observations from the field also supported this assumption since various interventions have been introduced in the communities to promote the physical activity level of elderly and obese people. For example, the installation of community and public parks in Communities A and B attracted elderly and obese people to have morning and evening exercise, while speed reducing interventions and provision of good street lighting along the street in Community C encouraged retired people to go out walking, jogging, and cycling in the early morning.[28,30,31]

The significant associations between positive attitudes towards public transport environments and sufficient physical activity have highlighted the critical role of supportive infrastructure. Conducive environments for public transport, attractiveness, and reasonable pricing are essential components making public transport options accessible and appealing. These findings align with international evidence, which underscores the necessity of well-designed public transport systems to support active travel behaviors.[10,32–35]

Active travel literacy, which includes understanding and exposure to active travel campaigns, also showed a strong relationship with sufficient physical activity. Educating the public about the health benefits of active travel through information dissemination, campaigns, personalized travel planning, training, and social marketing is crucial. These educational efforts can significantly enhance the adoption of active travel behaviors.[16] For instance, public campaigns that highlight the health benefits of walking and cycling can motivate individuals to make healthier lifestyle choices. Furthermore, the proactive involvement of local leaders, environmental and urban planners, and community members is essential to foster a culture of active travel and physical activity.[36,37]

It is worth noting that the non-significant association between attitudes towards walking and cycling environments and sufficient physical activity may stem from consistently high mean attitudes observed for these conditions. Participants already held favorable views on the conduciveness of the environment and community behavior related to walking and cycling, resulting in limited variability. This ceiling effect might have reduced the likelihood of detecting a significant association, as positive attitudes alone might have been insufficient to drive behavior change without complementary infrastructure improvements.[38]

The interplay between physical activity and active travel is complex and multifaceted. Active travel behaviors or active lifestyles result from a series of decisions and interactions between individual factors, social and built environments, and supportive policies and strategies.[13,16–18] Individual preferences, such as health consciousness and environmental awareness, interact with the availability of safe and accessible transport infrastructure. Social influences, including family and community norms, also shape transport behaviors.[16,17] This study's findings underscore the need for comprehensive approaches that address these multiple facets.

This study's strengths include the use of exploratory factor analysis combined with multivariable analysis, which provided a nuanced understanding of the associations between attitudes and sufficient physical activity while controlling for confounders. However, the study's generalizability is limited, as the sites were part of a specific project promoting walking and cycling. Future studies should include a broader range of areas nationwide. The reliance on community leaders for sample recruitment and questionnaire distribution might have introduced selection and information bias, highlighting the need for random sampling in future research to ensure representativeness. Additionally, the cross-sectional design limited causal inference, and the sample size calculation, while effective for estimating prevalence, was not optimized for detecting associations between attitudes and physical activity. Translating broad attitudinal themes into policy may require focusing on specific elements, such as enhancing public transport accessibility and affordability and promoting active travel literacy.

Conclusion

Positive attitudes towards public transport environments and active travel literacy were significantly associated with higher levels of sufficient physical activity. These findings suggest that while public transport infrastructure and active travel literacy are crucial, targeted improvements are needed in areas with lower support. Policymakers should focus on enhancing the convenience, attractiveness, and affordability of public transport. Educational campaigns that emphasize the benefits and safe practices of active travel could further strengthen active travel literacy.

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Conflicts of Interests

The authors declare no conflict of interest.

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Associated Factors of Influenza B Infection from a Staff-introduced Outbreak in a Prison, Buriram Province, Thailand, September–November 2023

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Abstract

On 17 Oct 2023, the Office of Disease Prevention and Control Region 9 Nakhon Ratchasima was notified of 570 influenza-like illness cases in a prison in Buriram Province, Thailand. An investigation was performed to confirm the outbreak and diagnosis, identify sources and risks, and provide recommendations. National surveillance database and prison records were reviewed, and an active case-finding in the prison targeted individuals with fever, cough, sore throat, runny nose, or myalgia between 20 Sep 2023 and 18 Nov 2023. Suspected cases were individuals who developed fever with at least one other symptom. Confirmed cases were suspected cases with a positive result based on the reverse transcription polymerase chain reaction technique. A total of 678 cases (attack rate 39.6%) were identified, including 28 confirmed influenza B cases. Three were admitted and there were no intubations or deaths. Vaccine coverage in the prison was 33.1%. Observations revealed overcrowding, poor ventilation, inadequate sick-person management, and a lack of hygiene facilities. A case-control study considering suspected and confirmed cases as true cases and symptom-free inmates as true non-cases identified exposure to close-range sneezing (odds ratio 2.03, 95% confidence interval 1.23–3.36) and sporadic face mask-wearing (odds ratio 1.67, 95% confidence interval 1.07–2.63) as significant risk factors after adjusting for other factors. Interventions included screening, early quarantine, event cancelation, and enhanced hygiene practices. The outbreak subsided within three weeks. We recommended the use of prison records to develop a surveillance system, improving sick staff management, increasing vaccine coverage, and reducing overcrowding.

Keywords: influenza, outbreak, prison, Buriram Province, Thailand

Introduction

Influenza is a contagious respiratory illness caused by influenza viruses. It can cause mild to severe illness with common symptoms including fever, cough, sore throat, runny nose, and myalgia. The disease mainly spreads through droplets. It has an incubation period of 1–4 days and a contagious period from one day before to seven days after the onset.[1] The disease is usually self-limited and often requires no treatment; however, an anti-influenza drug such as oseltamivir can shorten the illness duration and minimize viral shedding.[2–4] Isolation and quarantine play a significant role in containing influenza pandemics.[5]

The influenza virus is a common cause of outbreaks in prisons.[6] Between 1 Jan 2022 and 7 Nov 2023, Thailand recorded 16 prison outbreaks, 11 of which were acute respiratory infections, including five influenza A and one unspecified influenza outbreak.[7] Influenza vaccination is crucial for preventing influenza outbreaks. The reported effectiveness of influenza vaccines varies by around 40%–60%.[8] Previous studies indicated that herd immunity can be achieved at a vaccine coverage of 50%.[9] Risk factors identified from previous investigations into influenza outbreaks include overcrowded conditions, proximity to influenza cases, and sharing utensils with others.[10–13]

On 17 Oct 2023, the Office of Disease Prevention and Control Region 9 Nakhon Ratchasima (ODPC 9) was notified of an outbreak in a prison in Nang Rong District, Buriram Province in the northeastern region of Thailand, involving 570 inmates with symptoms of influenza-like illness (ILI). ODPC 9 and Buriram Provincial Public Health Office conducted a joint field investigation on 18–19 Oct 2023 to confirm the outbreak and diagnoses, describe the epidemiological characteristics, find possible sources, determine factors associated with influenza infection, and provide control measures to prevent future outbreaks for both inmates and staff.

Methods

To confirm the outbreak, we reviewed influenza case numbers in Nang Rong District, Buriram Province, from the national surveillance databases (2018–2023) and compared them to the 5-year median. Mean ILI cases were calculated from the nurse station's patient records.

Descriptive Study

Active case finding was conducted among all inmates and prison staff. An ILI case was defined as any person with at least one symptom, including fever (body temperature ≥37.8 °C or history of fever), cough, sore throat, runny nose, or myalgia, between 20 Sep 2023 and 18 Nov 2023. A suspected case was an ILI case who had a fever and at least one other symptom. Suspected cases who tested positive by reverse transcription polymerase chain reaction (RT-PCR) were categorized as confirmed cases. ILI case findings after 18 October (the investigation period), were performed by prison staff through daily screening until no new cases were identified for 14 days.

We collected nasopharyngeal swabs from suspected cases with symptom onset within three days for COVID-19 screening using an antigen test kit and for influenza testing via RT-PCR at the Bamrasnaradura Infectious Disease Institute or the Department of Medical Science, Ministry of Public Health. Influenza-positive specimens with a cycle threshold (CT) value <25 underwent whole genome sequencing to identify a subtype.

We conducted a walkthrough survey of dormitories, toilets, shops, cooking areas, dining areas, and quarantine and isolation rooms in the prison. Direct observations were conducted on dining, drinking, and personal hygiene behaviors, and on how ILI control measures were implemented. Prison staff were interviewed about their work activities and personal hygiene practices. In-depth interviews were conducted with staff who worked at the nurse's station, focusing on the processes and protocols of ILI surveillance, screening, quarantine, and isolation systems.

Analytical Study

A case-control study was conducted to identify factors associated with influenza infection among inmates in Zone 1, which was the zone that had the highest attack rate. We used a structured questionnaire to collect self-reported data on demographic characteristics such as age, gender, weight and height, underlying diseases, symptoms, risk behaviors, and vaccine history (influenza and COVID-19). Body mass index (BMI) was calculated from self-reported weight and height by weight (kg) per height (m^2) and categorized as underweight (BMI <18.5 kg/m^2), normal (BMI 18.5–24.9 kg/m^2), overweight (BMI 25.0–29.9 kg/m^2), and obese (BMI ≥30.0 kg/m^2). We defined suspected and confirmed cases as true cases and symptom-free inmates (no ILI symptoms) as true non-cases (controls).

Statistical Analysis

We described continuous data using medians with interquartile range (IQR) and frequencies and proportions for categorical data. Univariable and multivariable logistic regression models were used to determine factors associated with influenza infection. Factors with a p-value <0.1, or factors that were previously associated with influenza infection from other studies, namely vaccination, were included in the multivariable logistic regression models. Odds ratios (OR) with 95% confidence intervals (CI) were calculated using R version 4.3.1. We used the "tidyverse" package for data management and the "lmtest" package for model diagnostic testing.

Ethics

Ethical clearance was waived as this investigation was conducted as part of a response to a disease outbreak. All results were aggregated without any individual-traceable data.

Results

National surveillance data (2018–2023) showed influenza cases in Nang Rong District exceeded the 5-year median starting on October 2022 and peaking in September 2023 (district: 360 versus 6; provincial: 3,630 versus 248 cases). Nurse station records reported 1,344 ILI cases from January–September 2023, averaging 149 cases per month (approximately five per day).

Descriptive Study

This prison was for inmates who had been sentenced to less than 20 years, with occupational training before release. In September 2023, it housed 1,713 individuals consisting of 88 staff and 1,625 inmates (1,489 male and 136 female) with four male zones (Zones 1, 2, and 3, and an elderly zone) and one female zone.

Following the active case finding and monitoring until the outbreak waned, 678 ILI cases were identified (4 staff, 674 inmates). The overall attack rate of cases was 39.6% (678/1,713). The attack rate among staff was 4.5% (4/88) and among inmates was 41.5% (674/1,625) (Table 1).

All staff were vaccinated in 2023 but only 33.1% (190/574) of interviewed inmates reported being vaccinated in the past 12 months (84 of 658 inmates interviewed were excluded from vaccine coverage calculation due to uncertainty about their vaccination status and timing).

Table 1. Distribution of ILI cases in staff and inmates by gender and zone in a prison, Nang Rong District, Buriram Province, Thailand, 20 Sep 2023 to 18 Nov 2023

	Number of ILI cases	Total	Attack rate (%)
Staff	4	88	4.5
Inmates			
Male			
Zone 1	457	710	64.4
Zone 2	115	316	36.4
Zone 3	40	298	13.7
Zone 4 (elderly)	27	84	32.1
Female	35	136	25.7
Total	678	1,713	39.6

Among the 658 interviewed inmates in Zone 1, 454 cases were identified. The median age of the cases was 30.5 years (IQR 14 years). Of these, 54 (11.9%) had underlying diseases, with hypertension, asthma, diabetes mellitus, and allergic rhinitis being the four most common conditions (Table 2).

Common symptoms of the cases were runny nose (69.1%), cough (63.4%), sore throat (60.4%), fever (50.7%), myalgia (48.5%), and headache (45.9%). Less common symptoms were fatigue, chill, dyspnea, conjunctivitis, diarrhea, and vomiting (17.4%, 16.4%, 8.2%, 4.6%, 4.6%, and 2.6%, respectively). Three cases developed viral pneumonia and there were no deaths or intubations.

Table 2. Characteristics of interviewed prison inmates in Zone 1 in a prison, Nang Rong District, Buriram Province, Thailand, 20 Sep 2023 to 18 Nov 2023 (n=658)

Characteristics	Inmates	ILI cases	Percentage of ILI cases among inmates
Interviewed	**658**	**454**	**69.0**
Median age (IQR) in years	**31.0 (13.0)**	**30.5 (13.0)**	**-**
Median BMI (IQR) in kg/m²	**22.9 (4.24)**	**22.9 (4.25)**	**-**
Underlying disease (%)	**74 (11.2)**	**54 (11.9)**	**73.0**
Hypertension (%)	14 (2.1)	8 (1.8)	57.1
Asthma (%)	10 (1.5)	6 (1.3)	60.0
Diabetes Mellitus (%)	6 (0.9)	4 (0.9)	66.7
Allergic Rhinitis (%)	4 (0.6)	4 (0.9)	100.0
Dyslipidemia (%)	2 (0.3)	2 (0.4)	100.0
Psychosis (%)	2 (0.3)	2 (0.4)	100.0
HIV infection (%)	2 (0.3)	1 (0.2)	50.0
Self-reported vaccine history from interview	**574**	**390**	**67.9**
Less than 12 months ago (%)	190 (33.1)	126 (32.3)	66.3
More than 12 months ago (%)	93 (16.2)	60 (15.4)	64.5
Never (%)	291 (50.7)	204 (52.3)	70.1

ILI: influenza-like illness. BMI: body mass index. IQR: interquartile range.

Between 21 Sep and 5 Oct 2023, four staff members experienced fever. All sick staff members were absent for one day and returned to work and wore masks while they still had flu-like symptoms. Two of them had symptom onset within four days before the first inmate cluster onset (5 Oct 2023). On 2 Oct 2023, a staff member took sick leave and returned to work the next day. This staff member had to work in Zone 1 because each staff member had to rotate to other zones every day due to a lack of personnel. There was a staff common room that facilitated staff interactions. There was no protocol for sick staff returning to work. Three days later, the first cluster occurred in Zone 1, leading to a subsequent increase in cases. On 12 Oct 2023, a group event involving inmates from all zones took place for one hour. Following this event, the number of cases rose and peaked on 16 Oct 2023. Staff initiated screening, quarantine, and isolation measures. After that, the number of cases began to decline, while the number of cases in Zones 2 and 3, and the female zone showed an increasing trend (Figure 1).

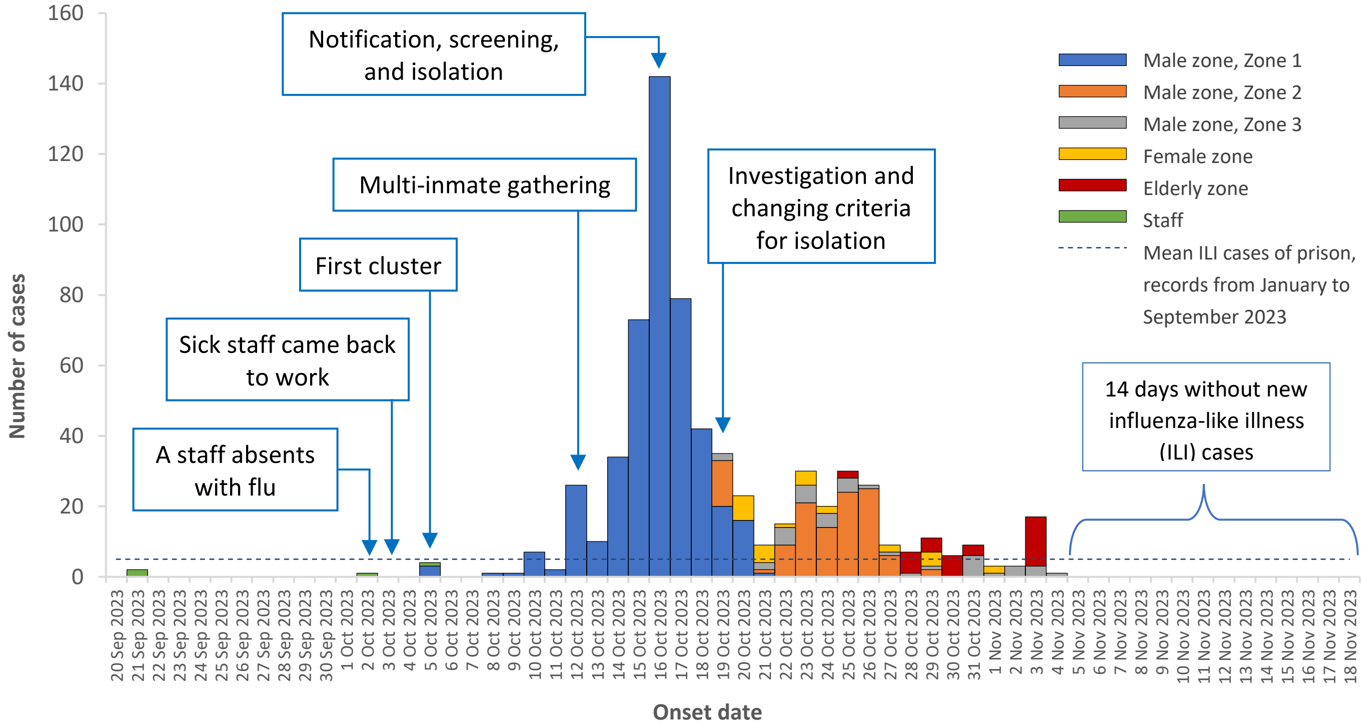

Figure 1. Epidemic curve of ILI cases in a prison, Nang Rong District, Buriram Province, Thailand, 20 Sep 2023 to 18 Nov 2023 (n=678)

Of the interviewed inmates in Zone 1, 29 nasopharyngeal swabs were collected from suspected cases, of which 28 (96.5%) tested positive for the influenza B virus. Whole genome sequencing revealed the presence of the B/Austria/1359417/2021 (B/Victoria lineage)-like virus strain with the V1A.3a.2 lineage in all three samples eligible for testing. Additionally, COVID-19 tests at the same time as the RT-PCR sample collection using antigen test kits returned negative results for all 29 cases.

The average space of an inmate in the prison was 1.2 m^2. Inmates shared personal items such as water glasses, utensils, and clothes with others. Although there were three hand wash basins, no soap was provided, and alcohol sanitizing gel was unavailable due to prison restrictions. Face masks provided by the prison were insufficient for all inmates. A shop within the prison allowed inmates to purchase items using fingerprint scans for payment, but there was no alcohol sanitizing gel or handwashing basins provided for inmates to use either before or after scanning. Inmates from Zone 3 could interact with those in Zone 1 while cooking in the canteen. No visitors were allowed inside the prison, but inmates could access on-site visits through a clear glass window and communicate using a phone. Visitors could only send money to inmates through the prison credit system.

ILI Surveillance, Screening, Quarantine, and Isolation Systems

Since 2022, the prison has implemented quarantine regulations for new or returning inmates including a 10-day quarantine for newcomers and a 5-day quarantine for returning inmates before entering a specific zone. Quarantined inmates were housed in a single building with multiple rooms where air ventilation was inadequate. Quarantine periods began when a room reached full capacity or had no new arrivals for three days. If an inmate in a room exhibited ILI symptoms, he or she would be isolated into a negative pressure room equipped with air-draining vents and the quarantine period of the rest would be reset.

In the nurse's station, the number of ILI cases was recorded and reported monthly to the prison director. While there were no specific outbreak detection criteria, staff would initiate fever and blood-oxygen desaturation screenings twice a day if they suspected an outbreak. Inmates showing symptoms would be sent to the nurse station or isolation room based on severity for a 7-day observation period. Initial treatment was provided by nurses with referrals to a hospital if conditions worsened. Vaccination records in the nurse's station showed discrepancies with less than 10% matching interview results due to record loss during inmate transfers.

After the investigation, cases were isolated for seven days after the onset of their symptoms. All gathering events were canceled and inter-zone contact was prohibited. Emphasis was placed on proper personal hygiene practices, including wearing masks, practicing social distancing, avoiding sharing personal items, and regular handwashing. Prison staff screened those with at least one ILI symptom twice daily for early detection and isolation until no new cases were reported for 14 days (completed on 18 Nov 2023). The ODPC 9 provided 4,000 face masks and 250 tablets of oseltamivir to the prison for severe or high-risk cases. However, control measures were not fully implemented due to the prohibition of alcohol gel in the prison for security concerns, and not all high-risk cases could be treated with oseltamivir due to national shortage.

Analytical Study

Interviews were conducted with 658 inmates in Zone 1 (92.7% of 710 inmates), of which 214 (32.5%) were true cases and 204 (31.0%) were true non-cases. The median (IQR) weight, height, and BMI among all inmates were 65 (12) kg, 1.70 (0.09) m, and 22.9 (4.2) kg/m^2, respectively. Significant risk behaviors from the univariable analysis included sporadic wearing of face masks, sleeping near sick inmates less than two meters), contact with a case in the past seven days, exposure to close-range sneezing less than two meters), and sharing utensils or clothes with others (p <0.05) (Table 3).

After multivariable analysis, sporadic wearing of face masks and exposure to close-range sneezing remained significant risk factors (adjusted OR 2.03, 95% CI 1.23–3.36) (Table 4). Diagnostic testing on this model showed no multi-collinearity.

Table 3. Result of univariable analysis showing factors associated with influenza infection among inmates in Zone 1 in a prison, Nang Rong District, Buriram Province, Thailand, 20 Sep 2023 to 18 Nov 2023 (n=418)

Factor	Cases with exposure/ total cases	Controls with exposure/ total controls	Crude odds ratio	95% confidence interval	*P*-value
Individual factors					
Influenza vaccine history (n=361)					
Non-vaccinated (reference group)					
Within 3 months	13/100	20/107	0.65	0.30–1.39	0.264
3–6 months ago	21/108	20/107	1.05	0.53–2.07	0.888
More than 6 months ago	56/143	57/144	0.98	0.61–1.58	0.942
Body mass index (n=363)					
Normal (reference group)					
Underweight	24/164	14/153	1.70	0.85–3.43	0.133
Overweight	15/155	20/159	0.74	0.37–1.51	0.414
Obese	4/144	7/146	0.57	0.16–1.98	0.541
Having underlying disease (n=418)	27/214	20/204	1.33	0.72–2.45	0.362
Behavioral factors					
Sporadic wearing of face mask (n=415)	138/212	105/203	1.74	1.17–2.58	0.005
Sleeping near sick inmates (<2 meters) (n=417)	137/213	103/204	1.77	1.19–2.62	0.004
Contact with a case in past 7 days (n=413)	122/212	96/201	1.48	1.01–2.19	0.046
No handwashing before eating, drinking, or touching their own face (n=415)	101/212	83/203	1.32	0.89–1.94	0.166
Exposed to close-range sneezing (<2 meters) (n=415)	105/213	60/202	2.30	1.53–3.45	<0.001
Sharing glasses and utensils with others (n=418)	88/214	62/204	1.60	1.07–2.40	0.022
Sharing clothes with others (n=418)	19/214	8/204	2.39	1.02–5.58	0.039
Receiving visitors (n=414)	62/211	69/203	0.81	0.53–1.22	0.314

Table 4. Factors associated with influenza infection among inmates in Zone 1 in a prison, Nang Rong District, Buriram Province, Thailand, 20 Sep 2023 to 18 Nov 2023

Factors	Adjusted odds ratio (95% confidence interval)
Sporadic wearing of face mask	1.67 (1.07–2.63)
Sleeping near sick inmates (<2 meters)	0.91 (0.49–1.65)
Contact with a case in past 7 days	1.29 (0.73–2.28)
Exposed to close-range sneezing (<2 meters)	2.03 (1.23–3.36)
Sharing glasses and utensils with others	0.96 (0.58–1.57)
Sharing clothes with others	1.68 (0.67–4.54)
Influenza vaccine history (ref=non-vaccinated)	
Within 3 months	0.69 (0.31–1.51)
3–6 months ago	1.16 (0.56–2.40)
More than 6 months ago	0.97 (0.59–1.61)

Discussion

A likely source of this influenza B outbreak was symptomatic staff who returned to work seven days after onset. This outbreak exhibited a higher attack rate (39.6%) compared to a previous influenza B outbreak in a nearby prison in Chaiyaphum Province in June 2023 (21.3%).[12] Risk factors identified included sporadic wearing of face masks and exposure to close-range sneezing.

Previous studies identified staff, new inmates, and visitors as common routes of disease introduction into prisons.[14] The absence of protocols for symptomatic staff members returning to work may have contributed to the current outbreak. Typically, sick staff members were absent for only a few days and returned to work during the contagious period of influenza, until seven days after onset.[1] Because of staff shortages, a 7-day absence was not feasible. Therefore, practical measures such as wearing masks while working at the prison and conducting daily symptom screenings for staff might have been more effective.

The average space for an inmate in this prison was 1.2 m^2. However, the recommended minimum space for Thai correctional facilities is 1.6 m^2 and the minimum space from the European Convention for the Prevention of Torture and Inhuman or Degrading Treatment or Punishment (CPT) standard is 4 m^2, both of which indicated the overcrowded condition of the prison.[15,16] There was no soap provided at the wash basin and no alcohol sanitizing gel for inmates to adequately wash their hands. These factors may have contributed to the spread of influenza within the prison.

Our analysis identified sporadic wearing of face masks and exposure to close-range sneezing as significant risk factors. These factors are consistent with findings from several other prison outbreak investigations.[10–13] Exposure to close-range sneezing is attributable to the overcrowded conditions of the prison. These factors are major obstacles to controlling respiratory infection outbreaks in prisons. Focusing on disease-introducing prevention and vaccination programs could be more effective measures.[8,9,14]

The vaccine coverage of inmates was 33.1%, which is lower than the 50% herd immunity threshold for influenza, and therefore its protective impact was limited.[9] However, many studies have shown the effectiveness of influenza vaccines in reducing hospitalization, intensive care unit admission, and death.[17–19] Vaccination of inmates, especially in vulnerable groups such as the elderly or those with underlying disease, is suggested.

The identified strain, B/Austria/1359417/2021 (B/Victoria lineage)-like virus was included in the 2023 World Health Organization recommended trivalent vaccine for the Southern Hemisphere, including Thailand.[20] The recommendation indicated that this influenza strain was circulating in Thailand and that herd immunity from the recommended vaccine could prevent this outbreak.

Control measures were initiated four days after the first peak of the outbreak, which had been delayed due to the absence of an ILI surveillance system. However, following the implementation of screening and isolation measures, case numbers steadily declined, indicating that early detection through screening of individuals with at least one ILI symptom and comprehensive isolation for seven days were effective in the prison context.

Limitations

Characteristics of ILI cases among the prison staff were unavailable. Since we only received numbers and the onset of ILI cases from the prison's staff screening between 19 Oct and 18 Nov 2023, other characteristics could only be described among all 454 ILI cases that the investigation team interviewed. We only had access to Zone 1 in the prison since no cases were reported from other zones prior to the investigation. This could have caused selection bias. The study design was case-control due to the ambiguous source of the population, despite interviewing >90% of inmates in Zone 1. The heights and weights of inmates were self-reported since anthropometric measurement tools were not available. Only 10% of interviewed inmates could have their vaccine history matched to the prison vaccine records due to the high inmate exchange rate. Finally, some inmates could not remember their last influenza vaccine date, thus recall bias may have occurred.

Conclusion

We identified an influenza B outbreak in a prison with an attack rate of 39.6%. There were no severe cases and no deaths. The viral strain identified by whole genome sequencing was the B/Austria/1359417/2021 (B/Victoria lineage)-like virus. Onset of the first cluster of cases occurred on 5 October, the peak on 16 October, and the last case on 4 Nov 2023. A possible source of the outbreak was staff returning to their work duties while still infectious. Sporadic wearing of face masks and exposure to close-range sneezing were identified as significant risk factors. Overcrowding, inadequate sick-person management, and lack of hygiene facilities were observed. Strict adherence to quarantine and isolation protocols and screening for any ILI symptoms to facilitate early detection and isolation were crucial for controlling this outbreak.

Recommendations

To prevent future influenza outbreaks in prison, prison staff should increase the availability of handwashing facilities with soap in common contact areas (shop, canteen, and nurse's station). Strict adherence to screening, quarantine, and isolation protocols is essential. Staff at the nurse's station should develop guidelines for sick staff who return to work. These could include requirements to stay at home during the contagious period, or if long leave during contagious periods is not possible, then wearing masks and handwashing, plus daily pre-work screening to consider ILI symptoms beyond fever would be helpful. Based on patient records in the nurse's station, information should be utilized to develop an ILI surveillance system in the prison. The occurrence of more than five cases per day should be considered a potential outbreak indicator. This threshold is adaptable by nurse station staff based on the results of this newly established surveillance system. Policymakers should focus on increasing vaccine coverage and reducing overcrowded conditions in the long term to improve the overall health of staff and inmates and prevent future outbreaks.

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Conflicts of Interests

No conflict of interest.

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Prevalence of Depressive Symptoms and Associated Factors among Cross Border Migrants in Thailand, 2023: a Mixed-methods Study

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Abstract

Depression is a significant global health issue, and migrants often face barriers to mental health care, resulting in undiagnosed depressive symptoms. Thailand accommodates many cross-border migrants from Cambodia, Lao PDR, and Myanmar (CLM), yet little is known about depressive symptoms in these populations. This study aims to address this gap. A mixed-methods study was therefore conducted to assess the prevalence of depressive symptoms and determine associated factors. Quantitative data were collected via a paper-based questionnaire, including the Patient Health Questionnaire-9 (PHQ-9), and analyzed using multiple logistic regression. Qualitative data from in-depth interviews were analyzed using content analysis. Of the 431 participants, who were mostly female (73.3%) and from Myanmar (97.9%), the prevalence of depressive symptoms was 23.9%. Having public insurance (adjusted odds ratio (AOR) 0.24, 95% confidence interval (CI) 0.13–0.43) and being employed (AOR 0.33, 95% CI 0.19–0.57) were significant protective factors. Alcohol consumption showed no association with depression. Qualitative findings reinforced the protective role of public insurance and highlighted employment as a critical factor in mental well-being. These results underscore a notable prevalence of depressive symptoms among CLM migrants, emphasizing the need for health policies that increase access to mental health care and support for this population. Further research should explore broader mental health factors among migrants to guide comprehensive policy development.

Keywords: depressive symptoms, mental health, migrants, Thailand

Introduction

In 2019, depression was the second most common mental disorder, affecting approximately 970 million individuals globally[1] and remained a leading contributor to years of healthy life lost due to disability, representing 5.6% of the total[2].

Despite the existence of various tools to detect early depression, marginalized groups face barriers to diagnosis and treatment due to stigma, limited awareness, and poor access to health care.[3,4] Migrants and refugees are particularly vulnerable, often experiencing health disparities in their host countries.[5-8]

Over three percent of the global population currently resides outside their home country, and migration is linked to heightened stress and depression. Among migrants in Thailand, approximately 2.6 million are registered workers. These populations face health disparities, including precarious legal status, language barriers, and unsafe living conditions.[9,10] During the COVID-19 pandemic, depression was a prominent concern, with the crisis exacerbating existing vulnerabilities among migrants.[11] The prevalence of depression among Myanmar migrants varies, with reported rates ranging from 13.0% to 14.4% in different contexts.[12, 13]

Addressing depression in migrant communities is critical, as untreated symptoms can develop into major depression, affecting the entire well-being of these populations. However, research on depressive symptoms among migrants in Thailand is sparse. This study therefore aims to investigate the prevalence of depressive symptoms among Cambodian, Lao PDR, or Myanmar (CLM) migrants in Thailand and identify factors associated with these symptoms.

Methods

We used an explanatory mixed-methods design with an emphasis on quantitative methods, using qualitative methods to explain the quantitative findings.

Quantitative Study

A cross-sectional survey was conducted between April and June 2023 in four provinces of Thailand, namely Chiang Rai, Ranong, Samut Sakhon, and Tak. These provinces were selected due to their high concentrations of migrant workers, particularly in labor-intensive sectors such as construction, agriculture, fisheries, and domestic services. These sectors often involve long working hours and physical labor, both of which can affect the mental health of migrants.

The study employed a convenience sampling method in collaboration with local non-governmental organizations (NGOs) that have direct engagement with migrant communities. Eligible participants were migrants aged 15 years or more, regardless of their citizenship or health insurance status. The target sample size was calculated using Cochran's formula (1977), which estimated a 39% prevalence of depressive symptoms, with a sample size of 461 to account for a 20% non-response rate. A total of 480 individuals were recruited, of which 49 were excluded for not being CLM nationals, resulting in 431 eligible participants.

Data was collected through paper-based, self-reported questionnaires, which were translated into four languages: Burmese, Khmer, Laotian, and Thai. To ensure proper comprehension and data accuracy, interpreters were available during the administration of the surveys. The questionnaire was divided into two sections: the first section collected demographic data, namely age, gender, education level, occupation, income, health insurance status, and alcohol consumption. The second section assessed depressive symptoms using the Patient Health Questionnaire-9 (PHQ-9). The PHQ-9 is a validated tool for identifying major depressive disorder where scores range from 0 to 27. The categorization for depressive symptoms was based on established scoring guidelines, where 0–4 indicates no or minimal symptoms, 5–9 indicates mild symptoms, 10–14 indicates moderate symptoms, 15–19 indicates moderately severe symptoms, and 20 or above indicates severe symptoms. The prevalence was determined based on participants with scores of 5 or higher, indicating at least mild symptoms. Before the survey, the questionnaire was reviewed by two independent experts and assessed for face validity by pre-testing it on 10 non-study participants.

Descriptive statistics were employed to summarize the demographic characteristics and prevalence of depressive symptoms. Frequencies and percentages were calculated for categorical variables while continuous variables were described using means and standard deviations, or medians and interquartile ranges, depending on their distribution. Chi-square tests were used for univariable analysis. Crude odds ratio (COR) and 95% confidence intervals (CI) were calculated. Variables with p-values less than 0.1 were included in the initial multivariable logistic regression model to identify factors independently associated with depressive symptoms. Results were presented as adjusted odds ratio (AOR) with 95% CI. R version 4.2.2 was used for all analyses. For the logistic regression model, depressive symptoms were dichotomized as no symptoms (PHQ-9 scores 0–4) versus at least one symptom (PHQ-9 scores >5)

Qualitative Study

The qualitative study aimed to provide deeper insights into the experiences of CLM migrants regarding their depressive symptoms and access to mental health care services. In-depth interviews were conducted with two groups: (i) NGO representatives with extensive experience working with migrant populations, and (ii) CLM migrants who had previously sought, or were currently receiving, mental health services.

The initial sample included six local NGO representatives, purposively selected for their expertise in migrant health. Subsequently, snowball sampling was used to recruit seven additional CLM migrants at risk of developing depressive symptoms, as identified by the NGOs. In total, 13 individuals were interviewed, aged 15 or more, including those with status and rights issues, both with and without health insurance. All participants were willing to participate and had accessible communication channels.

Interviews were semi-structured, lasting between 30 and 60 minutes, and were conducted in diverse settings, including NGO offices and public hospitals. All interviews were audio-recorded with participant consent and were transcribed verbatim. The qualitative data were analyzed using content analysis, which involved organizing transcripts and field memos, followed by free coding and theme identification. The analysis focused on understanding the barriers to mental health care, the social and psychological factors influencing depressive symptoms, and the perspectives of both service providers and recipients. The qualitative data were collected before the quantitative finding was finalized. The findings from the qualitative study were then integrated with the quantitative results to provide a comprehensive understanding of the factors affecting depressive symptoms among CLM migrants in Thailand.

Ethics

The study received ethical approval from the "Institute for the Development of Human Research Protections" (IHRP No. 110-2565). Written informed consent was obtained from almost all of the participants. Verbal consent was given by those who were uncomfortable providing written consent or those who were illiterate. Fingerprints were used instead of signatures for illiterate participants. Field translators provided study details to non-Thai-speaking participants. All participants were assured that they could withdraw from the study at any time.

Results

Quantitative Study

A total of 480 migrants were screened, and 431 participants were deemed eligible after excluding 49 individuals who were not CLM nationals. The final sample predominantly consisted of females (73.3%). Slightly more than half (51.5%) were aged between 30–44 years, 23.2% were aged 15–29 years, and only 1.9% were aged over 60 years. Most participants were Myanmar nationals (97.9%), followed by Laos (1.9%) and Cambodia (0.2%) (Table 1).

Most participants (88.6%) had been living in Thailand for over 4 years, while 3.0% had been in the country for less than a year. Regarding education, 58.5% had completed high school, 30.9% had completed primary school, and 3.3% had obtained a diploma or bachelor's degree. Most (79.4%) participants were employed (Table 1).

In terms of health insurance, 55.9% were covered by the Health Insurance Card Scheme (HICS), 39.9% were not insured, and 4.2% had private insurance. The average monthly income was 7,476 Thai baht (THB) (US$ 212.39), with a median income of 8,000 THB (US$ 227.27). Most (87.9%) never consumed alcohol, while 5.8% consumed alcohol once a month or less, and 6.3% drank more frequently (Table 1).

The prevalence of depressive symptoms was 23.9%, with the majority (76.1%) having minimal or no symptoms. The severity of mild and severe depression was 19.0% and 0.5%, respectively (Figure 1).

Table 1. Demographic characteristics of migrants included in the study (n=431)

Characteristic	No.	Percent
Gender		
Male	115	26.7
Female	316	73.3
Age group (years)		
15–29	100	23.2
30–44	222	51.5
45–59	101	23.4
≥60	8	1.9
Nationality		
Cambodian	1	0.2
Laotian	8	1.9
Myanmar	422	97.9
Health insurance		
None	172	39.9
HICS	241	55.9
Private	18	4.2
Length of stay in Thailand (years)		
<1	13	3.0
1–2	19	4.4
3–4	17	3.9
>4	382	88.6
Highest education level achieved		
None	31	7.2
Kindergarten	1	0.2
Primary School	133	30.9
High School	252	58.5
Diploma	8	1.9
Bachelor	6	1.4
Employment status		
Unemployed	89	20.6
Employed	342	79.4
Income per month (US$)		
Mean (SD)	212.39 (136.22)	
Median (IQR)	227.27 (142.05–284.09)	
Frequency of alcohol consumption		
Never	379	87.9
Once a month or less	25	5.8
At least fortnightly	10	2.3
Twice weekly or more	17	4.0

US$ 1 equals 35.2 Thai baht (as of 6 Dec 2023). HICS: Health Insurance Card Scheme. IQR: interquartile range. SD: standard deviation.

Univariate analysis showed that males and individuals older than 37 years had a slightly higher odds of depression, though neither were statistically significant. A monthly income above 8,000 THB (US$ 227.27) was weakly associated with an increased odds of depression (COR 1.47, 95% CI 0.94–2.3). Participants insured with HICS (COR 0.17, 95% CI 0.1–0.29) and the employed (COR 0.24, 95% CI 0.15–0.4) had a significantly lower odds of depression (Table 2).

Being in Thailand for more than years and having completed high school were also protective, but these factors were not statistically significant. Alcohol consumption showed a borderline association (COR 1.83, 95% CI 0.98–3.4). In multivariable analysis, HICS insurance (AOR 0.24, 95% CI 0.13–0.43) and employment (AOR 0.33, 95% CI 0.19–0.57) remained significant protective factors, reducing the odds of depression by approximately 70%. Length of stay and education showed a protective trend but were not statistically significant, while alcohol consumption was not significant (AOR 1.28, 95% CI 0.64–2.57) (Table 2).

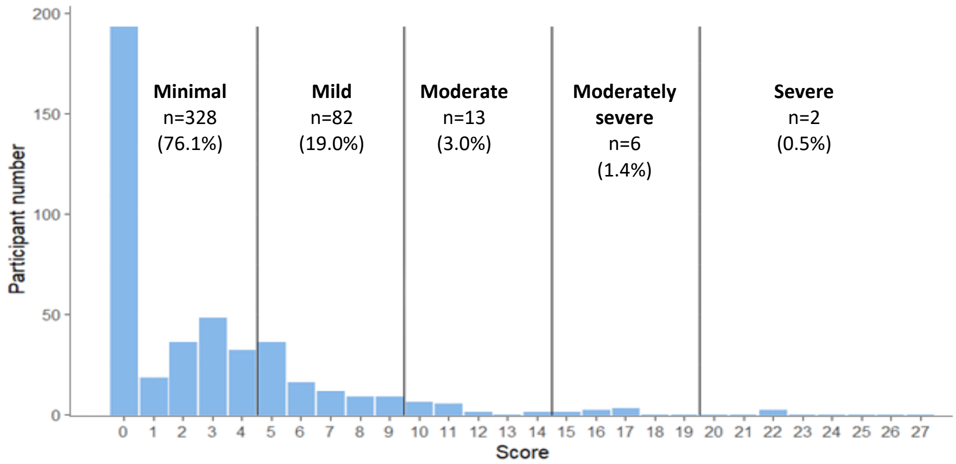

Figure 1. Distribution of depressive symptoms among the survey participants (n=431)

Table 2. Univariable and multivariable logistic regression analyses to identify factors associated with symptoms of depression among migrants (n=431)

Participant characteristics	No symptoms (n=328)		Symptoms (n=103)		COR (95% CI)	AOR (95% CI)
	No.	Percent	No.	Percent		
Gender						
Female	242	76.6	74	23.4	Ref.	-
Male	86	74.8	29	25.2	1.10 (0.67–1.81)	-
Age group (years)						
≤37 (below and equal to the median)	177	78.0	50	22.0	Ref.	-
>37 (above the median)	151	74.0	53	26.0	1.24 (0.80–1.94)	-
Health insurance						
No health insurance	103	59.9	69	40.1	Ref.	Ref.
Health Insurance Card Scheme (HICS)	216	89.6	25	10.4	0.17* (0.10–0.29)	0.24* (0.13–0.43)
Private insurance funds	9	50.0	9	50.0	1.49 (0.56–3.95)	1.83 (0.65–5.18)
Length of stay in Thailand (years)						
<4	27	55.1	22	44.9	Ref.	Ref.
≥4	301	78.8	81	21.2	0.33* (0.18–0.61)	0.63 (0.32–1.23)
Education						
Below high school	117	70.9	48	29.1	Ref.	Ref.
High school and above	211	79.3	55	20.7	0.64† (0.41–0.99)	0.66 (0.40–1.08)
Employment						
Unemployed	47	52.8	42	47.2	Ref.	Ref.
Employed	281	82.2	61	17.8	0.24* (0.15–0.40)	0.33* (0.19–0.57)
Income per month (per month)						
≤8,000 THB (≤US$ 227.27) (below and equal to the median)	175	79.5	45	20.5	Ref.	Ref.
>8,000 THB (>US$ 227.27) (above the median)	153	72.5	58	27.5	1.47 (0.94–2.30)	0.98 (0.58–1.67)
Alcohol use						
Non-alcoholic drinking	294	77.6	85	22.4	Ref.	Ref.
Drinker (at least once a month or less)	34	65.4	18	34.6	1.83 (0.98–3.40)	1.28 (0.64–2.57)

**P-value <0.001. †P-value <0.05. US$ 1 equals 35.2 Thai baht (as of 6 Dec 2023). COR: crude odds ratio. AOR: adjusted odds ratio. CI: confidence interval. Ref: reference.*

Qualitative Study

We identified three main themes from the interviews: (i) the role of public health insurance in protecting against depressive symptoms, (ii) the impact of employment on mental health, and (iii) alcohol and substance use as coping mechanisms for depression.

For the first theme, participants highlighted the benefits of public health insurance, particularly the HICS, which offers coverage similar to the Universal Coverage Scheme for Thai citizens. The annual cost is 2,100 THB (US$ 59.66), which includes a health check, with a minimal co-payment of 30 THB (US$ 0.85) per visit. This scheme helps alleviate the financial burden of medical treatment, supporting better access to mental health care.

"At first, I was not concerned whether I had health insurance or not. But I needed to seek medical treatment. At that time, I had not yet acquired any health insurance…Therefore, I had to pay all the medical expenses by myself (200–300 THB per month), which was a long-term treatment (every two months). …Following news from Facebook, I learned that there was government health insurance available. Consequently, (after being insured by the HICS) I did not have to pay for the treatment by myself."—Male migrant worker, 27 years old

"I had to pay 480 THB a month for my own treatment. My family paid for me for the first two or three months. Then my mom said she could not afford it anymore; she wanted me to stop the treatment but I did not want to. I was depressed…So, I paid for my own health insurance coverage–2,100 THB a year… I feel so much better since I have been treated."—Female migrant worker, 25 years old

For the second theme, employment constituted a pivotal factor in protecting migrants against depression. The absence of employment resulted in financial stress, as highlighted in the interviews.

"During the period when I did not have a job, I felt lots of stress. This was because finding a job was difficult…I did not have any income. I needed income to support daily expenses."—Female migrant psychiatric patient, 25 years old.

Regarding the third theme, some interviewees mentioned that substance abuse and alcohol use became a method of coping with stress, especially during the COVID-19 period.

"Stress is mostly related to alcohol addiction. During the COVID-19 pandemic, many migrants became alcohol addicted."—Thai NGO representative, 34 years old

"Migrant workers in the fishing sector usually use substances when facing stressful situations or mental health problems. This is because it is cheap and easy to obtain, and the workers do not have better ways to cope with stress. Moreover, they use many types of substances…"—Thai NGO representative, 35 years old.

Discussion

This study is one of the first to examine depressive symptoms among cross-border migrants in Thailand, revealing that 23.9% of migrants reported such symptoms, which is significantly higher than the 2.2% prevalence in the general Thai population.[14] This discrepancy may arise from the fact that the national figure pertains to diagnosed depression, while our study focused on depressive symptoms, highlighting a potential difference in measurement and timing between the two studies.

Our findings also show higher rates of depression than those in other studies among Myanmar migrants. For instance, Kaesornsri et al. (2019) reported a prevalence of depression of 11.9% in Myanmar workers in Samut Sakhon,[15] and Chomchoei et al. (2020) reported a 12.0% prevalence among Thai hill-tribe adults.[16] These findings suggest that migrant populations may be more vulnerable to depression, likely influenced by factors such as socioeconomic status, access to health care, and country of origin. However, the prevalence of depression among urban refugees and asylum seekers in Thailand is even higher (39.5%),[17] due to their more precarious legal status and lack of access to health care compared to CLM migrants.

Several factors were identified as protective against depressive symptoms in our study. Migrants with access to public health insurance, particularly the HICS, reported lower rates of depression. Access to affordable health care reduces financial stress, which is often a significant contributor to mental health issues. These findings are consistent with another study,[18] which showed that access to health insurance can reduce depression among migrants.[18] Interestingly, private insurance did not have the same effect, possibly due to the informal employment sector. While access to private insurance is limited among migrants, its potential association with depression requires further exploration.

Length of stay in Thailand was a protective factor, with migrants who had resided in the country for more than four years reporting lower rates of depressive symptoms. This finding was supported by a study in Canada in 2012, suggesting that recent immigrants were at higher risk of postpartum depression than

Canadian-born women of European descent.[19] However, another study reported that long-stay immigrants faced a higher risk of depressive symptoms than short stayers.[20] This suggests that longer stays may facilitate better integration into Thai society, providing access to health care, social networks, and support systems. However, some studies suggest that prolonged exposure to stressors may increase the likelihood of depression, underscoring the need for further research on the long-term mental health impacts of migration.[20]

Education also played a key role, with migrants who had completed at least high school being less likely to report depressive symptoms in our study. This is consistent with the literature suggesting that higher education provides better social support, cognitive resilience, and access to resources, which can help buffer the symptoms of depression.[21–23] Moreover, a key finding is the link between alcohol consumption and depressive symptoms. Cobb et al. (2020) noted that depressive symptoms often led to increased alcohol use among Hispanic immigrants in the US.[24] while Chavan et al. (2022) found that the prevalence of mental health issues and substance abuse, including alcohol, was significantly higher in migrants than in the general population.[25] Evidence suggests that individuals with alcohol dependence are about four times more likely to have major depression. Some studies propose that depressive disorders lead to early alcohol dependence, while others suggest the reverse.[26,27] Thus, the relationship between alcohol use and depression is complex and likely bidirectional.

Our findings suggest several policy implications. First, expedited nationality verification for undocumented migrants is needed to ensure that they receive timely access to health care. Policies that expand educational opportunities for migrants could be developed to improve their mental resilience and social support networks. Alcohol control measures should target both migrants and the broader population. Healthcare providers should screen for alcohol use and depression in migrants. Addressing these issues can enhance mental health outcomes for migrants in Thailand and promote a more inclusive health care system.

Limitations

Some limitations of our study remain and should be acknowledged. First, the cross-sectional study design limits the ability to establish causal relationships and understand the directionality between various factors and depressive symptoms. Second, the study was conducted in four Thai provinces, which may not fully represent the experiences of all migrant groups in Thailand. Third, undocumented migrants and those with severe depressive symptoms were difficult to reach, potentially underestimating the prevalence of depression, especially among those reluctant to participate due to legal concerns. Fourth, self-reported data, particularly on sensitive topics such as alcohol use and health insurance status, may introduce bias, as participants might underreport these behaviors due to privacy concerns. Fifth, the use of the PHQ-9 tool, though validated in some countries, may not be as accurate as a clinical diagnosis, and its applicability in Laos and Myanmar needs further validation. Sixth, the small qualitative sample as well as the use of purposive sampling may limit the depth and generalizability of the findings, not capturing the full range of migrant experiences. Seventh, the convenience sampling method restricts the ability to quantitatively generalize the findings to all migrant groups, particularly those working/living in remote areas. Additionally, Myanmar migrants appeared to be over-represented in the sample, which may limit the transferability of the findings to other nationals. Lastly, the study did not examine barriers to access health care for migrants with depressive symptoms, an important area for future research.

Future studies should incorporate clinically diagnosed depression, explore access to health care, and utilize longitudinal designs. Expanding geographical coverage, ensuring a more balanced representation of different nationalities, and including other mental health issues beyond depressive symptoms would provide a more comprehensive understanding of migrant health needs. Strengthening collaborations between public health providers and NGOs could improve access to mental health care, especially for undocumented migrants.

Recommendations

This study highlights the need for targeted interventions to reduce depressive symptoms among migrants in Thailand. Expanding access to the HICS and simplifying enrollment for undocumented migrants could improve access to mental health services. Regular mental health screenings in high-stress sectors such as construction and fisheries would enable early detection of depression. Integrating mental health services within trusted NGO networks and offering culturally sensitive resources could also reduce stigma and improve the well-being of migrants.

Conclusion

This study found that 23.9% of migrants in four Thai provinces exhibited depressive symptoms. Significant factors associated with a higher prevalence of depressive symptoms were a lack of public health insurance and being unemployed. Alcohol consumption, short length of stay in Thailand, and not completing secondary education, presented with increased odds of depression though without statistical significance. Addressing these risks and improving the support for the mental well-being of migrant communities are crucial. Further research is needed to explore mental health across a wider range of migrants and other aspects of mental illnesses.

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Conflicts of Interests

The authors declare that they have no competing interests.

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Adverse Events Occurred within 30 Minutes Following COVID-19 Vaccination at Bang Sue Central Vaccination Center, Bangkok, Thailand, July to December 2021

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Abstract

COVID-19, with a case fatality rate of 0.98%, requires treatment based on severity of illness. Vaccination is crucial for preventing virus spread and decreasing severity of illness, yet it may lead to side effects. This study explored the 30-minute adverse events following immunization (AEFI) after receiving COVID-19 vaccination at Bang Sue Central Vaccination Center (BSCVC). Data (demographic profile of vaccines, type of vaccines administered for the first and second doses and occurrence of AEFI within 30 minutes) from 871,446 vaccine administrations from July to December 2021 at BSCVC were analyzed. There were 386 occurrences (44.29 per 100,000 doses of vaccine administered) of 30-minute AEFI, with females experiencing AEFI twice as often as males. The highest AEFI rate was with the ChAdOx1 nCoV-19 vaccine (62.68 cases per 100,000 vaccinations). First doses resulted in nearly four times more AEFI than second doses. When considering the second dose, the heterologous regimens had more AEFI than the homologous regimens. Common AEFI symptoms included dizziness/lightheadedness (34%), palpitations/chest tightness (16%), and numbness (11%). No serious AEFI was observed. Further monitoring of AEFI across all vaccination centers in the country should be done including causality assessments for any serious AEFI reported.

Keywords: Adverse events following immunization, COVID-19, COVID-19 vaccine, Immunization, Thailand

Introduction

Coronavirus disease 2019 (COVID-19), caused by the severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2), typically presents with mild or no symptoms in 80% of cases. In some individuals, symptoms resemble those of upper respiratory tract infections, while around 15% may experience coughing and fever. Elderly individuals are more prone to severe symptoms, including fever, and respiratory issues. In approximately five percent of cases, this can progress to critical illness leading to respiratory failure and shock.[1] The mortality rate in Thailand increased from 0.50% in March 2021 to 0.98% by December 2021.[1,2] Preventive measures recommended by the Ministry of Public Health (MOPH) included wearing masks, frequent hand washing, social distancing, and quarantine.[3,4]

Additionally, efforts have been made to develop COVID-19 vaccines to bolster the body's defenses against the virus, reducing its severity upon entry into the body. This also aids in the establishment of herd immunity, where a significant portion of the global population develops immunity to COVID-19, either through natural infection or vaccination, thereby limiting its spread. COVID-19 vaccines utilize various manufacturing technologies, classified into four main processes: 1) Genetic vaccines (e.g., Pfizer-BioNTech and Moderna); 2) Viral vector vaccines (e.g., Oxford-AstraZeneca, CanSino Biologics, Johnson & Johnson, and Gamaleya); 3) Protein subunit vaccines (e.g., Novavax); and 4) Inactivated virus vaccines (e.g., Sinovac and Sinopharm).[4]

In Thailand, four COVID-19 vaccines were being deployed in 2021: the CoronaVac vaccine from Sinovac (SV), ChAdOx1 nCoV-19 vaccine from AstraZeneca (AZ), BNT162b2 vaccine from Pfizer (PZ, Comirnaty, BioNTech), and mRNA-1273 vaccine from Moderna (MD). These vaccines were administered at the Bang Sue Central Vaccination Center (BSCVC) in Bangkok from May 2021 and March 2022, which provided over five million vaccine doses to Thai individuals aged 18 and above, in line with the MOPH guidelines. The BSCVC served as a large and centralized facility, providing various vaccines allocated by the MOPH during the vaccination campaign aimed at building immunity.

Adverse events following immunization (AEFI) have been generally observed, with most reactions being mild or not severe. These adverse events might result from vaccine administration, but can also stem from other factors unrelated to the vaccine. The Department of Disease Control, MOPH, categorizes AEFI into two types primary types: 1) Allergic reactions and severe allergies, which can be further subdivided into two groups.[4] The first group consists of side effects, which are predictable reactions such as pain, swelling, and warmth at the injection site, and systemic symptoms (e.g., fever, body aches, fatigue, nausea, vomiting, dizziness, and headache). The second group involves hypersensitivity reactions, which occur when the body has allergic reactions to the vaccine or its components. These reactions can range in severity, with the most severe form being anaphylaxis. 2) Stress-related reactions, which are physical responses to stress during vaccination, accompanied by typical post-vaccination side effects. These reactions can occur with all types and batches of vaccines although the mechanism of disease development is not yet clear. Symptoms of stress-related reactions vary and may include lightheadedness, abdominal cramps, nausea, dizziness, high blood pressure, rapid heartbeat, and dissociative neurological symptoms such as weakness, tingling, abnormal body movements, speech difficulties, brain-like symptoms, or seizures. Most often, symptoms occur within 30 minutes after vaccination, but in some cases, they may occur hours or days later. Typically, individuals in this group tend to recover within 1–3 days, although some may experience symptoms for longer periods. Nonetheless, individuals in this group can return to their daily activities as usual.

This study focused on investigating the 30-minute AEFI of COVID-19 vaccination at the BSCVC, specifically in Thai individuals aged 18 and above. The study period, from May 2021 to March 2022, coincided with the MOPH's vaccination efforts aimed at establishing immunity. The BSCVC adhered clinical practice guidelines for anaphylaxis from July to December 2021, ensuring the safe administration of COVID-19 vaccines.[5]

Methods

This was a retrospective descriptive study that investigated AEFI among individuals who received the COVID-19 vaccine and had a history of completing either homologous or heterologous vaccinations. The homologous vaccination group was the vaccine group in which the first and second doses were the same type, e.g., SV-SV, AZ-AZ, PZ-PZ, and MD-MD, and the heterologous vaccination group was the vaccine group in which the first and second doses were different types, e.g., SV-AZ, AZ-PZ, and PZ-MD. The study included only individuals who received two doses of the vaccine at the BSCVC between July and December 2021, encompassing a total of 871,446 vaccine doses administered.

Data collection involved gathering information from reports of AEFI from the BSCVC electronic database during a 30-minute observation period after vaccination. The process included several steps. First, evaluation of AEFI by trained medical personnel or volunteer rescue workers, who were assigned to observe and report symptoms every 15 minutes after vaccination. Second, if necessary, individuals exhibiting symptoms were referred to the primary care unit for further assessment and care by medical personnel or volunteer rescue workers. Finally, documentation of personal information, vaccine type received, and details of the adverse events categorized by vaccine type and injection sequence were documented on patient report forms.

The data were analyzed descriptively, presenting results as percentages of AEFI and focusing on its primary signs or symptoms, i.e., chief complaint. To explore the differences in AEFI within the 30-minute observation period after COVID-19 vaccination, subgroup analysis on different injection sequences was conducted to examine various variables within each subgroup. Additionally, the study assessed acute adverse events occurrence during the observation period among individuals who received various homologous heterologous vaccination strategies.

Ethics

This research was approved by the Research Ethics Committee of the Faculty of Medicine, Chulalongkorn University (IRB No. 0507/65, approval date 21 Jul 2023, expiration date 20 Jul 2024), and received project extension approval from the Research Ethics Committee for Human Research for fiscal year 2024 (IRB/IEC No. 017/2565, approval date 13 Sep 2023).

Results

A total of 871,446 vaccine doses were administered during the study period. There were 386 occurrences of 30-minute AEFI after receiving the COVID-19 vaccine in the study sample (44.29 per 100,000 doses of vaccine administered). It was found that AEFI occurred more frequently in females, approximately twice as often as in males. Primarily, AEFI occurred in the age group of 18 to less than 20 years, with a rate of 134.51 per 100,000 doses. The highest occurrence of AEFI was associated with the ChAdOx1 nCoV-19 vaccine, at a rate of 62.68 per 100,000 doses. Additionally, individuals who received their first doses experienced AEFI almost four times more frequently than those who received their second doses (Table 1).

Table 1. Demographic and vaccination data at Bang Sue Central Vaccination Center, July to December 2021

Variables	Number of vaccine doses administered (n=871,446)		Number of AEFI reports (n=386)	
	Number	Percent	Number	Rate per 100,000 doses*
Gender	**871,446**	**100.00**	**386**	**44.29**
Male	410,314	47.08	105	25.59
Female	461,132	52.92	281	60.94
Age group (years)	**871,446**	**100.00**	**386**	**44.29**
18–<20	15,612	1.79	21	134.51
20–29	263,370	30.22	98	37.21
30–39	197,772	22.69	89	45.00
40–49	159,784	18.34	70	43.81
50–59	118,918	13.65	37	31.11
60–69	52,486	6.02	30	57.16
70–79	33,126	3.80	20	60.38
≥80	29,118	3.34	21	72.12
Unknown	1,260	0.14	0	0.00
Type of vaccine	**118,918**	**13.65**	**386**	**44.29**
CoronaVac (Sinovac)	15,612	1.79	23	21.22
ChAdOx1 nCoV-19 (AstraZeneca)	263,370	30.22	294	62.68
BNT162b2 (Pfizer)	197,772	22.69	59	24.37
mRNA-1273 (Moderna)	159,784	18.34	10	19.26
Injection sequence	**871,446**	**100.00**	**386**	**44.29**
First dose	435,723	50.00	305	70.00
Second dose	435,723	50.00	81	18.59
Vaccine regimen†	**871,446**	**100.00**	**386**	**44.29**
Homologous	381,016	43.72	259	67.98
Heterologous	490,430	56.28	127	25.90

**Proportion of AEFI occurrence per 100,000 doses of vaccine administered. †Combining numbers of AEFI occurrence of the first and the second doses. AEFI: adverse events following immunization.*

The analysis of AEFI stratified by age group also found that AEFI occurred more frequently when receiving the first dose than the second dose in all age groups. When considering the second dose, AEFI occurred more frequently in those receiving heterologous regimens than in those receiving homologous regimens in the under-20 age group and the 20–59 age group, except for the age group over 60 years, where the opposite trend was observed. However, for overall, the second dose of heterologous regimens had a higher AEFI occurrence compared to that of the homologous regimens, with rates of 22.03 per 100,000 doses and 14.21 per 100,000 doses, respectively (Table 2).

Additionally, the reporting rate of primary signs and symptoms of AEFI across all age groups were dizziness/lightheadedness, palpitations/chest tightness, and numbness, ranked as the first, second, and third most common symptoms, respectively (Table 3).

Table 2. Number and rate of 30-minute adverse events following immunization (AEFI) by vaccine regimen, dosage, and age group at Bang Sue Central Vaccination Center, July to December 2021

Vaccine regimen and dosage	Age group (years)							
	18–<20		20–59		≥60		Total	
	No. of AEFI (No. of vaccine injection)	Rate per 100,000 doses*	No. of AEFI (No. of vaccine injection)	Rate per 100,000 doses*	No. of AEFI (No. of vaccine injection)	Rate per 100,000 doses*	No. of AEFI (No. of vaccine injection†)	Rate per 100,000 doses*
Overall	**21 (15,612)**	**134.51**	**294 (739,844)**	**39.74**	**71 (114,730)**	**61.88**	**386 (870,186)**	**44.36**
First dose	**14 (7,806)**	**179.35**	**232 (369,922)**	**62.72**	**59 (57,365)**	**102.85**	**305 (435,093)**	**70.10**
Second dose	**7 (7,806)**	**89.67**	**62 (369,922)**	**16.76**	**12 (57,365)**	**20.92**	**81 (435,093)**	**18.62**
Homologous	2 (7,796)	25.65	15 (137,953)	10.87	10 (44,257)	22.60	27 (190,006)	14.21
Heterologous	5 (10)	50,000.00	47 (231,969)	20.26	2 (13,108)	15.26	54 (245,087)	22.03

**Proportion of AEFI occurrence per 100,000 doses of vaccine administered. †Excluding the records whose variables age were missing (1,260 doses).*

Table 3. Number and rate of signs and symptoms of 30-minute adverse events following immunization (AEFI) by age group at Bang Sue Central Vaccination Center, July to December 2021

Signs and symptoms	Age group (years)							
	18–<20		20–59		≥60		Total	
	Number of vaccine injections (n=15,612)		Number of vaccine injections (n=739,844)		Number of vaccine injections (n=114, 730)		Number of vaccine injections (n=870,186†)	
	No. of AEFI	Rate per 100,000 doses*	No. of AEFI	Rate per 100,000 doses*	No. of AEFI	Rate per 100,000 doses*	No. of AEFI	Rate per 100,000 doses*
Dizziness/lightheadedness	6	38.43	101	13.65	27	23.53	134	15.40
Palpitations/chest tightness	3	19.22	50	6.76	10	8.72	63	7.24
Numbness	2	12.81	36	4.87	6	5.23	44	5.06
Headache	1	6.41	23	3.11	5	4.36	29	3.33
Fainting	3	19.22	21	2.84	4	3.49	28	3.22
Nausea	2	12.81	19	2.57	3	2.61	24	2.76
Vomiting	0	0.00	9	1.22	5	4.36	14	1.61
Rash	0	0.00	13	1.76	0	0.00	13	1.49
Pain, swelling, redness, and warmth at the injection site	1	6.41	8	1.08	1	0.87	10	1.15
Fatigue, weakness, lack of energy	2	12.81	3	0.41	3	2.61	8	0.92
Muscle pain	1	6.41	3	0.41	2	1.74	6	0.69
Diarrhea	0	0.00	0	0.00	0	0.00	0	0.00
Other symptoms	0	0.00	8	1.08	5	4.36	13	1.49
Total	**21**	**134.51**	**294**	**39.74**	**71**	**61.88**	**386**	**44.36**

**Proportion of primary signs or symptoms reported per 100,000 doses of vaccine administered. †Excluding the records whose variables age were missing (1,260 doses).*

Among 386 AEFI found, majority of individuals experiencing adverse events reported primary symptoms such as dizziness, palpitations/chest tightness, numbness, and headache (Table 4).

The analysis results of AEFI occurrence among various types of homologous and heterologous vaccination strategies were shown in detail in Table 5–7. When combining the AEFI numbers of both doses, the AZ-AZ regimen (ChAdOx1 nCoV-19 (AZ) vaccine for the first and second doses) had the highest occurrence (99.63 per 100,000 doses) among homologous vaccination regimens, while the AZ-PZ regimen (ChAdOx1 nCoV-19 (AZ) vaccine for the first dose and BNT162b2 (PZ) vaccine for the second dose) had the highest occurrence (30.31 per 100,000 doses) among heterologous vaccination regimens (Table 5).

Table 4. Number and proportion of primary signs and symptoms associated with 30-minute adverse events following immunization (AEFI) of COVID-19 vaccine at Bang Sue Central Vaccination Center, July to December 2021 (n=386)

Signs and symptoms	Number of occurrences	Percentage among reported event
Dizziness/lightheadedness	134	34.72
Palpitations/chest tightness	63	16.32
Numbness	44	11.40
Headache	29	7.51
Fainting	28	7.25
Nausea	24	6.22
Vomiting	14	3.63
Rash	13	3.37
Pain, swelling, redness, and warmth at the injection site	10	2.59
Fatigue, weakness, lack of energy	8	2.07
Muscle pain	6	1.55
Diarrhea	0	0.00
Other symptoms	13	3.37

Table 5. Number of 30-minute adverse events following immunization (AEFI) by vaccine regimen and type

Vaccine type and vaccination regimen*	Number of vaccine administrations (n=871,446)		Number of AEFI (n=386)	
	Number	Percentage	Number	Rate per 100,000 doses†
Homologous type*	**381,016**	**43.72**	**259**	**67.98**
SV-SV	104	0.01	0	0.00
AZ-AZ	223,832	25.69	223	99.63
PZ-PZ	105,182	12.07	26	24.72
MD-MD	51,898	5.96	10	19.27
Heterologous type*	**490,430**	**56.28**	**127**	**25.90**
SV-AZ	216,564	24.85	44	20.32
SV-PZ	22	<0.01	0	0.00
SV-MD	0	0.00	0	0.00
AZ-SV	0	0.00	0	0.00
AZ-PZ	273,802	31.42	83	30.31
AZ-MD	26	<0.01	0	0.00
PZ-AZ	4	<0.01	0	0.00
PZ-MD	6	<0.01	0	0.00
MD-PZ	6	<0.01	0	0.00
Total	**871,446**	**100.00**	**386**	**44.29**

**Vaccine regimens are listed in chronological order before and after according to the vaccination policy. †Proportion of AEFI occurrence per 100,000 doses of vaccine administered. SV is the CoronaVac vaccine from Sinovac, AZ is the ChAdOx1 nCoV-19 vaccine from AstraZeneca, PZ is the BNT162b2 vaccine from Pfizer (PZ, Comirnaty, BioNTech), and MD is the mRNA-1273 vaccine from Moderna.*

The most common AEFI symptoms in the homologous group were dizziness/lightheadedness, followed by numbness, palpitations/chest tightness and headache (Table 6). Similarly, in individuals receiving heterologous vaccination, the most frequent AEFI symptoms in the heterologous group were dizziness/lightheadedness followed by palpitations/chest tightness, fainting and nausea (Table 7).

Furthermore, the analysis of 30-minute AEFI in individuals receiving homologous vaccination (Table 6), categorized by dose sequence and vaccine type, revealed that the ChAdOx1 nCoV-19 vaccine had the highest incidence, with 99.63 events per 100,000 doses. The most common AEFI symptoms associated with the ChAdOx1 nCoV-19 vaccine were dizziness/lightheadedness, followed by numbness, palpitations/chest tightness and headache, predominantly occurring after the first dose. Similarly, in individuals receiving heterologous vaccination (Table 7), the ChAdOx1 nCoV-19 vaccine had the highest incidence, with 28.96 events per 100,000 injections. The most common AEFI symptoms associated with the ChAdOx1 nCoV-19 vaccine were dizziness/lightheadedness, followed by palpitations/chest tightness, fainting, nausea and rash, predominantly occurring after the first dose.

Table 6. 30-minute adverse events following immunization (AEFI) in individuals receiving homologous vaccination, stratified by dose sequence and vaccine type (n=381,016)

Signs and symptoms	All AEFI	Rate per 100,000 doses *	CoronaVac vaccine (SV)						ChAdOx1 nCoV-19 vaccine (AZ)						BNT162b2 vaccine (PZ)						mRNA-1273 vaccine (MD)					
			Number of vaccine injections						Number of vaccine injections						Number of vaccine injections						Number of vaccine injections					
			n=104		n=52		n=52		n=223,832		n=111,916		n=111,916		n=105,182		n=52,591		n=52,591		n=51,898		n=25,949		n=25,949	
			All dose AEFI	Rate per 100,000 doses *	1st dose AEFI	Rate per 100,000 doses *	2nd dose AEFI	Rate per 100,000 doses *	All dose AEFI	Rate per 100,000 doses *	1st dose AEFI	Rate per 100,000 doses *	2nd dose AEFI	Rate per 100,000 doses *	All dose AEFI	Rate per 100,000 doses *	1st dose AEFI	Rate per 100,000 doses *	2nd dose AEFI	Rate per 100,000 doses *	All dose AEFI	Rate per 100,000 doses *	1st dose AEFI	Rate per 100,000 doses *	2nd dose AEFI	Rate per 100,000 doses *
Dizziness/ lightheadedness	86	22.57	0	0.00	0	0.00	0	0.00	72	32.17	64	57.19	8	7.15	11	10.46	10	19.01	1	1.90	3	5.78	1	3.85	2	7.71
Numbness	40	10.50	0	0.00	0	0.00	0	0.00	40	17.87	38	33.95	2	1.79	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00
Palpitations/ chest tightness	35	9.19	0	0.00	0	0.00	0	0.00	26	11.62	23	20.55	3	2.68	4	3.80	4	7.61	0	0.00	5	9.63	4	15.41	1	3.85
Headache	25	6.56	0	0.00	0	0.00	0	0.00	24	10.72	23	20.55	1	0.89	1	0.95	1	1.90	0	0.00	0	0.00	0	0.00	0	0.00
Fainting	13	3.41	0	0.00	0	0.00	0	0.00	8	3.57	6	5.36	2	1.79	5	4.75	4	7.61	1	1.90	0	0.00	0	0.00	0	0.00
Nausea	12	3.15	0	0.00	0	0.00	0	0.00	11	4.91	9	8.04	2	1.79	1	0.95	1	1.90	0	0.00	0	0.00	0	0.00	0	0.00
Vomiting	10	2.62	0	0.00	0	0.00	0	0.00	9	4.02	9	8.04	0	0.00	1	0.95	1	1.90	0	0.00	0	0.00	0	0.00	0	0.00
Fatigue, weakness, lack of energy	7	1.84	0	0.00	0	0.00	0	0.00	5	2.23	4	3.57	1	0.89	1	0.95	0	0.00	1	1.90	1	1.93	1	3.85	0	0.00
Pain, swelling, redness, and warmth at the injection site	7	1.84	0	0.00	0	0.00	0	0.00	7	3.13	7	6.25	0	0.00	0	0.00	0		0	0.00	0	0.00	0	0.00	0	0.00
Rash	7	1.84	0	0.00	0	0.00	0	0.00	6	2.68	5	4.47	1	0.89	0	0.00	0	0.00	0	0.00	1	1.93	1	3.85	0	0.00
Muscle pain	5	1.31	0	0.00	0	0.00	0	0.00	5	2.23	5	4.47	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00
Diarrhea	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00
Other symptoms	12	3.15	0	0.00	0	0.00	0	0.00	10	4.47	10	8.94	0	0.00	2	1.90	1	1.90	1	1.90	0	0.00	0	0.00	0	0.00
Total	**259**	**67.98**	**0**	**0.00**	**0**	**0.00**	**0**	**0.00**	**223**	**99.63**	**203**	**181.39**	**20**	**17.87**	**26**	**24.72**	**22**	**41.83**	**4**	**7.61**	**10**	**19.27**	**7**	**26.98**	**3**	**11.56**

Proportion of primary signs or symptoms reported per 100, 000doses of vaccine administered. SV: Sinovac. AZ: AstraZeneca. PZ: Pfizer. MD: Moderna.

Table 7. 30-minute adverse events following immunization (AEFI) in individuals receiving heterologous vaccination, stratified by dose and vaccine type (n=490,430)

Signs and symptoms	All AEFI	Rate per 100,000 doses *	CoronaVac vaccine (SV)						ChAdOx1 nCoV-19 vaccine (AZ)						BNT162b2 vaccine (PZ)						mRNA-1273 vaccine (MD)					
			Number of vaccine injections						Number of vaccine injections						Number of vaccine injections						Number of vaccine injections					
			n=108,293		n=108,293		n=0		n=245,198		n=136,914		n=108,284		n=136,920		n=5		n=136,915		n=19		n=3		n=16	
			All dose AEFI	Rate per 100,000 doses *	1st dose AEFI	Rate per 100,000 doses *	2nd dose AEFI	Rate per 100,000 doses *	All dose AEFI	Rate per 100,000 doses *	1st dose AEFI	Rate per 100,000 doses *	2nd dose AEFI	Rate per 100,000 doses *	All dose AEFI	Rate per 100,000 doses *	1st dose AEFI	Rate per 100,000 doses *	2nd dose AEFI	Rate per 100,000 doses *	All dose AEFI	Rate per 100,000 doses *	1st dose AEFI	Rate per 100,000 doses *	2nd dose AEFI	Rate per 100,000 doses *
Dizziness/ lightheadedness	48	9.79	10	9.23	10	9.23	0	0.00	27	11.01	19	13.88	8	7.39	11	8.03	0	0.00	11	8.03	0	0.00	0	0.00	0	0.00
Palpitations/ chest tightness	28	5.71	3	2.77	3	2.77	0	0.00	12	4.89	8	5.84	4	3.69	13	9.49	0	0.00	13	9.49	0	0.00	0	0.00	0	0.00
Fainting	15	3.06	4	3.69	4	3.69	0	0.00	10	4.08	10	7.30	0	0.00	1	0.73	0	0.00	1	0.73	0	0.00	0	0.00	0	0.00
Nausea	12	2.45	4	3.69	4	3.69	0	0.00	6	2.45	3	2.19	3	2.77	2	1.46	0	0.00	2	1.46	0	0.00	0	0.00	0	0.00
Rash	6	1.22	0	0.00	0	0.00	0	0.00	6	2.45	3	2.19	3	2.77	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00
Headache	4	0.82	1	0.92	1	0.92	0	0.00	1	0.41	1	0.73	0	0.00	2	1.46	0	0.00	2	1.46	0	0.00	0	0.00	0	0.00
Numbness	4	0.82	0	0.00	0	0.00	0	0.00	2	0.82	1	0.73	1	0.92	2	1.46	0	0.00	2	1.46	0	0.00	0	0.00	0	0.00
Vomiting	4	0.82	0	0.00	0	0.00	0	0.00	3	1.22	2	1.46	1	0.92	1	0.73	0	0.00	1	0.73	0	0.00	0	0.00	0	0.00
Pain, swelling, redness, and warmth at the injection site	3	0.61	1	0.92	1	0.92	0	0.00	1	0.41	0	0.00	1	0.92	1	0.73	0	0.00	1	0.73	0	0.00	0	0.00	0	0.00
Fatigue, weakness, lack of energy	1	0.20	0	0.00	0	0.00	0	0.00	1	0.41	1	0.73	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00
Muscle pain	1	0.20	0	0.00	0	0.00	0	0.00	1	0.41	1	0.73	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00
Diarrhea	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00
Other symptoms	1	0.20	0	0.00	0	0.00	0	0.00	1	0.41	1	0.73	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00
Total	**127**	**25.90**	**23**	**21.24**	**23**	**21.24**	**0**	**0.00**	**71**	**28.96**	**50**	**36.52**	**21**	**19.39**	**33**	**24.10**	**0**	**0.00**	**33**	**24.10**	**0**	**0.00**	**0**	**0.00**	**0**	**0.00**

**Proportion of primary signs or symptoms reported per 100, 000doses of vaccine administered. SV: Sinovac. AZ: AstraZeneca. PZ: Pfizer. MD: Moderna.*

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Discussion

This study revealed that 30-minute AEFI predominantly occurred in females compared to males, approximately twice as often, which aligned with previous studies such as Zahid MN's study in Bahrain in 2021.[6] Females experience a higher incidence of AEFI than males, possibly due to stronger immune responses influenced by hormonal factors, such as estrogen, which enhances immune activity.[7,8] Females are also more likely to report symptoms, leading to higher recorded AEFI rates.[9] Additionally, standard vaccine doses, not adjusted for body weight, may cause proportionally stronger effects in females.[10] Genetic differences also contribute to varying immune responses by gender.[11] Additionally, AEFI incidence was higher in the younger age group, particularly in those aged 18 to less than 20 years, with 134.51 cases per 100,000 vaccine doses. Several studies have reported an increased incidence of AEFI in younger populations. For instance, a study by Joshi et al in 2021 noted a higher rate of AEFI in individuals aged 16–29 years, with rates of 128 cases per 100,000 doses.[12] Similarly, an analysis by Jeon et al in 2021 found that individuals aged 18–24 experienced the most frequent AEFI.[13] Younger individuals tend to experience more AEFI due to their more robust immune responses, which can result in stronger inflammatory reactions.[14] Additionally, younger populations may report symptoms more frequently, leading to higher incidence.[15] Hormonal fluctuations and higher metabolic rates in younger people may also contribute to increased vaccine reactions.[8,16] Psychological factors, such as anxiety, could amplify the perception of AEFI.[17]

This study found immediate AEFI occurred higher among the first dose than the second dose. This might be partially explained by the fact that the vaccine type injected the most and with the highest AEFI rate in this study was ChAdOx1 nCoV-19 vaccine. This was consistent with several previous studies that reported higher AEFI occurrence after receiving the first dose than the subsequent doses among ChAdOx1 nCoV-19 vaccine recipients.[18,19] Another possible reason could be higher concern of both recipients and healthcare personnel at the center for the adverse effects after receiving the first dose than the second one.

When considering both the first and second doses together, there was a noticeable difference in AEFI occurrence between the two vaccination strategies, with higher AEFI incidence in homologous vaccination compared to heterologous vaccination. But the difference could be explained by multiple factors or mechanisms such as vaccine type, host response, or boosting immunity. When focusing on the second vaccine dose, however, it was found that heterologous regimens had AEFI more than the homologous regimens which might be mainly resulted from boosting immunity, which is consistent with the study of Polack et al. in 2020.[20] As demonstrated in study, stratifying AEFI occurrences of various vaccination strategies and sequences by age can help revealing significant insights into demographic influences on vaccine safety.[13] These findings highlight the need for tailored vaccination strategies that consider both efficacy and safety across different populations.

The most common AEFI symptoms observed included dizziness/lightheadedness, palpitations/chest tightness, numbness and headache, most of which were not serious. These findings differ from other studies such as Alhazmi A's study in Saudi Arabia in 2021, where fatigue and local pain were the most common AEFI.[21] No serious side effects or AEFI were noted, at least immediately following vaccination.

This study has several important strengths. First, it was a large population-based study, which provided a greater opportunity to detect rare AEFI, compared to a small study. Second, the study was able to estimate the incidence of immediate AEFI, which is of critical importance for public health policy makers in planning immunization service delivery and resource allocation, particularly in terms of manpower and budget.

Limitations

A limitation of the study is that the data was only collected from a specific vaccination center. Therefore, the results of this study cannot be used as a proxy for the incidence of AEFI in different contexts of other vaccinations. Additionally, this study focused on the primary signs or symptoms of the AEFI occurring within 30 minutes. These might not include other less concerned symptoms occurred during the period or AEFI that may occur in the following hours or days after vaccination. Hence, these findings do not give a comprehensive assessment of COVID-19 vaccine safety.

Conclusion

Overall, the study highlights the importance of ongoing AEFI surveillance and monitoring, particularly concerning different vaccination strategies and vaccine types. The research findings indicate that the occurrence of AEFI varies among different vaccine formulations, with a higher incidence in heterologous vaccination compared to homologous vaccination. AEFI is more common after the first dose than after the second dose. However, there should be a comprehensive study of AEFI occurrence from all vaccination centers nationwide in the future with extended monitoring period, e.g., asking individuals and healthcare personnel to report any serious signs/symptoms or illness requiring hospitalization within a month post-vaccination, and followed by a causality assessment for any serious AEFI found.

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Conflicts of Interests

The authors declare that there is no conflict of interest.

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One Health Approach Synergy in Animal Health and Public Health: Thailand Perspectives on Two IHR/PVS Assessments

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Abstract

Thailand gained experience in assessing the International Health Regulations (IHR) and Performance of Veterinary Services (PVS) through the IHR-PVS national bridging workshops in 2014 and 2022. These workshops employed an interactive methodology, including identification of gaps, scenario analysis, and the development of multisectoral collaboration. Participants from various sectors engaged in discussions, identified gaps in cooperation, and proposed strategies to strengthen coordination. To strengthen Thailand's commitment to the One Health approach, the Thai government has prioritized efforts to enhance the understanding and implementation of this unifying approach among decision-makers, develop comprehensive health governance through the revision of governance structures and establish coordination units, strengthen joint surveillance systems, improve joint investigation procedures, establish a robust risk assessment framework, develop effective risk communication strategies, and engage communities in One Health initiatives. By addressing these areas, Thailand aims to build a more resilient health system capable of preventing, detecting, and responding to zoonotic diseases with a streamlined response to health emergencies.

Keywords: One Health approach, International Health Regulations, Performance of Veterinary Services, Thailand

Introduction

The International Health Regulations (IHR) and the Performance of Veterinary Services (PVS) frameworks, established by the World Health Organization (WHO) and the World Organization for Animal Health (WOAH), respectively, are pivotal in global health security. The IHR primarily addresses human health, while the PVS targets animal health and veterinary services. Despite focusing on different aspects, both frameworks converge on shared objectives—preventing and controlling diseases, ensuring effective surveillance, and responding to public health threats, especially zoonotic diseases. However, the challenge of inter-sectoral coordination at the animal-human interface remains significant, with many countries reporting this as a critical weakness.[1]

The One Health approach, recognized by the American Veterinary Medical Association, promotes a collaborative, multidisciplinary effort across human, animal, and environmental health sectors.[2] This approach is important given that many contemporary infectious diseases, such as rabies, Ebola, avian influenza, severe acute respiratory syndrome (SARS), Middle East respiratory syndrome (MERS), and coronavirus disease 2019 (COVID-19), originate from animal pathogens. The interrelationship between the One Health approach and the IHR-PVS bridging workshop is that they both emphasize the enhancement of global health security[3] by improving the capacity of countries to prevent, detect, and respond to public health threats, particularly diseases associated with pathogens transmitted from animals to humans.

Thailand has organized two IHR-PVS national bridging workshops. The first pilot workshop was held from 26–27 Mar 2014 and the second from 20–22 Jul 2022. The workshops aimed to improve the capacity of Thailand to implement and comply with guidelines issued by both the IHR and PVS, focusing on enhancing the ability to effectively deal with zoonotic disease threats in the country. The concept of multisectoral approaches to public sector governance was adopted to promote good governance and constructive, practical dialogue to strengthen the coordination of operations and enhance effectiveness.[1] Upon completion of the workshops, they were expected to achieve improved alignment and strengthened synergies between the capacity-building approaches and strategies of human and animal health services in Thailand.

Methods

The IHR-PVS national bridging workshops involved an interactive approach and a process with materials, scenarios, IHR-PVS matrix, and facilitation tools.[4] The workshop was divided into seven sessions that were organized in a step-by-step format from gap identification to the development of multisectoral collaboration to prevent and control zoonotic diseases.[3,5] The process consisted of: (1) defining the outbreak scenarios; (2) examining different case studies, and diagnosing the collaboration for the technical areas; (3) filling the identified gaps on the IHR-PVS matrix, and collecting data from the IHR and PVS tools; (4) extracting and compiling results from previous IHR and joint external evaluation assessments; (5) drafting joint activities and plans; (6) fine-tuning the joint activities and plans; and (7) focusing on the way forward and establishing linkages with other mandated plans.[6]

Representative participants from diverse sectors, including health, agriculture, and environmental management, were engaged in comprehensive discussions of the IHR, PVS, One Health concept, and national perspectives. Participants engaged in the outbreak scenario to better conceptualize and willingly embrace opportunities for joint important technical areas. The outbreak scenarios involving 4–5 diseases in each IHR-PVS bridging workshop. Rationale of the diseases in outbreak scenarios used during the IHR-PVS assessment workshops is shown in Table 1. Participants evaluated the effectiveness of collaboration between the veterinary and public health sectors.[7]

The workshop began with the convenors introducing the IHR-PVS matrix, which is a tool designed to visualize the interface between human and animal health systems. Working groups were tasked with plotting their technical areas onto the matrix, allowing them to match their identified gaps to relevant indicators and visualize areas of common interest where the sectors could collaborate.[8] Building on the previous assessment, participants reviewed reports from the joint external evaluation and PVS evaluation, and then extracted key findings and recommendations into their particular technical areas and identified priority activities that could enhance future intersectoral collaboration.

Results

The two national workshops were convened with the primary objective of exploring Thailand's perspectives on the IHR Monitoring Framework and the WOAH PVS Pathway, particularly in the context of enhancing One Health synergy between animal health and public health. These workshops aimed to demonstrate how the outputs and outcomes from both the WHO and WOAH assessment frameworks can be leveraged to identify gaps and opportunities for improving coordination and collaboration at the animal–human interface.

The group discussions centered on past outbreak scenarios of zoonotic diseases, highlighting variations in collaborative efforts across different disease contexts. Participants noted that well-known diseases such as zoonotic avian influenza, rabies, and COVID-19 demonstrated strong multisectoral collaboration. In contrast, diseases such as salmonellosis and brucellosis (diseases related to food safety) were identified as areas of weaker collaboration, often being relatively neglected. Discussions also emphasized that antimicrobial resistance has seen improved collaboration, largely driven by advancements in policy development and increased awareness.

The IHR-PVS matrix analysis revealed notable progress between the first and second IHR-PVS workshops. In the initial workshop, field investigation, response, and laboratory capacity were rated negatively. However, in the second workshop, a significant improvement was evident, with positive ratings given for these areas and scores above average. Improvements also extended to other areas, including coordination, education, and training. Despite this, systemic gaps persisted in nearly half of the technical areas. Key challenges were identified in finance, human resource capacity, technical-level coordination, surveillance, and legislation, with additional gaps observed in risk assessment and communication.

Table 1. Rationale of the diseases in outbreak scenarios used during the IHR-PVS assessment workshops

Disease	1st workshop	2nd workshop	Rationale
Rabies	✓	✓	Rabies is a notable zoonotic disease and ranks as the fourth priority in Thailand. The rabies control program in Thailand demonstrates that intersectoral collaboration can be mobilized to prevent and contain disease spread. This includes mass immunization campaigns, stray dog population control, post-exposure prophylaxis for humans, and public awareness activities.
Avian influenza	✓	✓	Avian influenza ranks as the top priority zoonotic disease for One Health in Thailand due to its potential to cause widespread outbreaks with severe economic and public health implications. Thailand has experienced outbreaks of high pathogenicity avian influenza in the past and demonstrated that multisectoral coordination can be used to conduct surveillance, investigations, and response in affected areas to lessen the effects of the disease. Travel and trade restrictions also demonstrate the economic dimensions of disease management, stakeholder awareness, commitment, and compliance.
Food safety	✓		Thailand has the ability to prevent outbreaks through enhancements to food safety practices via the institutional strengthening of supply chain management. Integration of food safety practices into One Health approaches will allow animal health, food safety, and human health to be included in the prevention and response to disease outbreaks. Improved coordination of stakeholders is also important in Thailand's food safety strategy.
Antimicrobial resistance	✓		Antimicrobial resistance (AMR) is a global challenge, caused by changing dynamics in the prevalence of resistant pathogens associated with the misuse and overuse of antibiotics. Thailand has two national integrated AMR strategies that embraces collaboration between the veterinary sector, public health sector, and environmental agencies around surveillance, education, and policy development to manage and contain AMR.
Salmonellosis		✓	Salmonellosis is a significant foodborne zoonotic disease in Thailand, which is mostly associated with improper handling and consumption of contaminated products. The prevalence of Salmonella in food animals and global trade demonstrates the need for comprehensive surveillance and control measures. Thailand is focusing on food safety practices and hygiene education to minimize the potential for large outbreaks and protect health.
Brucellosis		✓	Thailand's experience with brucellosis serves as the value of joint investigations and intersectoral collaboration for disease control. In humans, brucellosis can result in chronic debilitating symptoms; in animals, it causes reproductive problems such as miscarriages and stillbirths, resulting in substantial economic losses in the livestock sector.
Coronavirus group		✓	Emerging coronaviruses, including SARS, MERS, and COVID-19, are among the most significant zoonotic threats globally to human health. These viruses are demonstrated to result in widespread outbreaks associated with severe social, economic, and political disruptions; all underscore the value of supporting an integrated One Health approach for the prevention and enrichment management of pandemics.

SARS: severe acute respiratory syndrome. MERS: Middle East respiratory syndrome. COVID-19: coronavirus disease 2019.

The first workshop focused on identifying and addressing critical gaps in Thailand's capacity for disease prevention and response. Participants highlighted several technical areas where improvements were needed, such as risk communication, joint surveillance, and emergency preparedness. The second workshop advanced the discussions by concentrating on policy advocacy and One Health governance, with a particular emphasis on community engagement at all administrative levels. Participants discussed strategies for enhancing the governance framework to better support intersectoral collaboration, as well as initiatives for educating and engaging communities to ensure their active participation in health initiatives.

The workshops explored the potential synergies between the PVS Pathway and IHR Monitoring Framework, which could be integrated into a One Health approach to enhance both human and animal health. The outcomes of the workshops highlighted the critical gaps and developed recommendations for strategic interventions to improve Thailand's health systems in the following technical areas.

Policy Advocacy

Enhancing the understanding and implementation of the One Health approach among key decision-makers is needed. The complexity of managing health challenges that intersect human, animal, and environmental health necessitates informing leadership at all levels. To address this, a targeted advocacy program should be developed and presented to executive decision-makers at both national and subnational levels. This program should be designed to deepen their comprehension of One Health principles and their practical applications, fostering a more integrated and collaborative approach to One Health governance.

The advocacy program should focus on the fundamentals of the One Health approach, emphasizing its importance in managing zoonotic diseases, antimicrobial resistance, and emerging infectious diseases. By highlighting current examples and lessons learned from previous health crises, the program aims to illustrate the tangible benefits of intersectoral collaboration. The sessions are tailored to the needs of decision-makers, ensuring that the information is relevant, actionable, and aligned with their responsibilities in shaping health policies and programs.

One Health Governance

The weakness of a comprehensive One Health governance system across all administrative levels emerged as a gap, impeding coordination efforts to address health challenges. To tackle this, a thorough review and revision of the existing governance structures needs to be undertaken at the central, regional, provincial, and district levels. This process aims to align governance mechanisms with current needs and challenges, ensuring a cohesive approach to health management. By integrating the One Health principles, this initiative seeks to foster stronger intersectoral collaboration, emphasizing the interconnectedness of human, animal, and environmental health in addressing zoonotic diseases and other public health threats.

A key component of this effort was recommended to conduct a functional assessment of the One Health system. The One Health Assessment Tool should be employed to evaluate the status of One Health institutionalization and national operationalization and identify gaps and areas for improvement. The insights derived from this process can inform the development of the further One Health strategic framework and action plan.

One Health Coordination Units should be established within each main sector. These units are tasked with ensuring cohesive and effective implementation of One Health initiatives, fostering collaboration, and streamlining communication across sectors. The establishment of these units will mark a significant step in institutionalizing the One Health approach within the governance structure. Additionally, the initiative led to the creation of a joint network of national experts on priority zoonotic diseases. This network will be designed to facilitate knowledge sharing, enhance collaboration, and strengthen the capacity to respond to zoonotic threats.

The culmination of these efforts was the endorsement of a revised One Health governance framework, which clearly defined the roles and responsibilities of all stakeholders. A memorandum of understanding shall be signed by the Ministries of Public Health, Agriculture and Cooperatives, and Natural Resources and Environment, and other relevant sectors, formalizing the governance system and reinforcing the commitment to a unified approach to health management. The validated and pilot-tested tools for assessing coordination and collaboration further ensure the framework's effectiveness and adaptability to various health contexts.

Joint Surveillance

The need to strengthen the joint surveillance systems became evident, highlighting a gap in the ability to detect and respond to emerging threats at the human-animal interface. A harmonized surveillance protocol on prioritized zoonotic diseases based on potential for causing pandemics should be established. The surveillance protocol for the joint surveillance plan should emphasize standardized data collection, a case definition for the syndromic surveillance system, and harmonized data sharing to enable timely interventions.

In the case of avian influenza surveillance, data sharing should include influenza-like illnesses and severe acute respiratory infections in humans while incorporating the monitoring of outbreaks and early warning signals in animals, including wildlife. This should include targeted sampling of livestock, testing of migratory birds, and laboratory findings. All shared data should be systematically analyzed by trained epidemiologists to identify trends and initiate timely and effective response measures.

Joint Investigation

The operational standard operating procedures (SOPs) for joint investigations were identified as a gap, potentially compromising coordinated responses during outbreaks. Addressing this issue requires the development of a comprehensive investigation guidance document, led by multidisciplinary investigators. The investigators can bring together epidemiologists from the animal health, public health, and environmental sectors, as well as key laboratory professionals, to ensure a holistic approach. The collaborative effort underscored the importance of the One Health approach, where joint investigations consider the interconnectedness of human, animal, and environmental health.

The guidance document aimed to standardize joint investigation procedures, fostering a seamless and efficient response to health emergencies. The working group recommended developing a joint contingency plan, incorporating coordination exercises to simulate current outbreak scenarios. These exercises not only test the readiness of the plan but also reinforce intersectoral collaboration. This will be accomplished by harmonizing a reporting platform that facilitates information sharing between the public health and animal health domains.

Risk Assessment

The joint framework for risk assessment and limited knowledge of risk assessment processes posed significant challenges to effective One Health management. Recognizing these gaps, a concerted effort was undertaken to develop a comprehensive risk assessment framework. The Joint Risk Assessment and Strategic Tool for Assessing Risks were recommended to evaluate and prioritize risks associated with zoonotic diseases based on their likelihood and potential impact. These risk assessments aimed to bridge the divides between animal health, public health, and environmental health to identify and mitigate health risks. The insights gained from these assessments provided evidence-based guidance for decision-making, helping to allocate resources effectively, develop policies, and enhance preparedness planning.

To support the framework's implementation, a train-the-trainer program should be launched, equipping a pool of trainers with the necessary skills to disseminate knowledge and build capacity across sectors. These trainers, alongside selected experts, can form a dedicated committee responsible for overseeing and guiding the risk assessment process. Another element of the initiative was the establishment of a mechanism to incorporate risk assessment results into risk management decision-making and communication. By doing so, the framework not only facilitates the identification of risks but also ensures that the findings are effectively used to inform policy and operational decisions. This mechanism enhanced the ability of health authorities to respond proactively to emerging threats, thereby improving overall health system resilience.

Risk Communication

The identification of gaps in risk communication, particularly the absence of SOPs, has underscored a weakness in crisis management. To address this, a focused effort should be initiated to develop comprehensive SOPs for efficient crisis communication, emphasizing the One Health approach. Recognizing the interconnectedness of animal health, human health, and environmental health, the initiative seeks to ensure that communication during health crises is streamlined across all sectors. An ad hoc working group comprising experts from animal health, public health, and environmental sectors should be formed to lead the SOP development process. This multisectoral team aims to integrate perspectives from all relevant fields, ensuring that the SOPs would be robust and applicable across different health emergencies.

The development process will begin with the formulation of policies and guidelines, laying a foundation for drafting the SOPs. These guidelines will be designed to promote synergy between the animal and public health sectors, reflecting the One Health approach. A series of co-training sessions and field tests will be conducted to validate the practicality and effectiveness of the SOPs. These exercises not only test the protocols but also facilitate collaboration and mutual understanding among professionals from various sectors. The field tests will simulate the current scenarios, ensuring that the SOPs can be effectively implemented in diverse crises.

Community Engagements

Strengthening One Health communication at the local level was identified as a gap, particularly in engaging communities to effectively manage zoonotic diseases. Recognizing the vital role of community engagement in achieving sustainable health outcomes, a coordinated approach should be developed to involve village volunteers in enhancing risk communication, surveillance, and response efforts. This initiative begins with the creation and signing of a memorandum of understanding between key sectors, including health, livestock, and environmental agencies. This will establish a formal framework for collaboration, emphasizing the importance of mobilizing community members as active participants in the One Health initiative, thereby fostering a sense of ownership and responsibility among local populations.

The development of a comprehensive training curriculum should be designed to harmonize risk communication, surveillance, and response efforts, with a strong focus on community engagement. This curriculum aimed not only to equip volunteers with the technical knowledge and skills needed to address zoonotic diseases and emerging infectious diseases but also to empower them as community leaders capable of fostering trust and cooperation among their peers. By integrating community engagement principles, the training ensures that volunteers can effectively communicate risks and mobilize community action, enhancing the overall impact of the One Health approach at the grassroots level.

A series of "training of trainers" programs should be conducted at regional levels, targeting personnel from disease prevention and control, livestock, and protected areas agencies. These programs should be followed by comprehensive training programs for village volunteers across selected provinces and high-priority districts. The volunteers, drawn from local communities, will be trained to implement coordinated risk communication strategies, conduct surveillance, and respond to outbreaks. This grassroots-level involvement ensures that the One Health approach is deeply embedded within local communities, promoting sustainable health practices.

The effectiveness of the trained volunteers should be closely monitored and evaluated to assess their impact on surveillance and communication efforts. This evaluation process can provide valuable insights into the strengths and areas for improvement within the volunteer network. The feedback will inform further refinements to the training curriculum, ensuring that it remains relevant and effective in addressing local health challenges. The finalized curriculum was subsequently endorsed and implemented as a core component of the One Health strategy at the community level.

The findings from the National Bridging Workshops in Vietnam, Indonesia, and Bhutan revealed common themes and challenges. Similar to Thailand, these countries emphasized the need for strengthening intersectoral collaboration, surveillance systems, and joint responses to zoonotic disease outbreaks. Vietnam's workshop participants highlighted gaps in inter-ministerial collaboration and the need for a mid-term review of its One Health framework, aligning with Thailand's findings on systemic gaps in coordination. Indonesia's delegates prioritized the development of legal frameworks and a harmonized surveillance system.[9] Bhutan focused on district-level coordination and capacity building for joint outbreak responses, corresponding to Thailand's need for enhanced multisectoral collaboration and workforce development.[10] However, areas like Vietnam's specific emphasis on environmental collaboration and Indonesia's advanced implementation of One Health curricula mark unique divergences from Thailand's context.[11]

Discussion

The One Health approach, which integrates human, animal, and environmental health, has gained large acceptance globally as a framework for managing complex health issues, especially zoonotic diseases. The approach is also used for combating newly recognized and re-emerging diseases of animal origin and contributions toward pandemic preparedness based on enhanced collaboration between veterinary, human health, and environmental services.[12] The IHR-PVS National Bridging Workshops conducted in Thailand have been instrumental in identifying gaps and developing strategies to strengthen of synergy between the animal health, human health and environmental sectors. These efforts align with global trends emphasizing the need for coordinated responses to health threats at the human-animal-environment interface.[4]

Policy advocacy emerged as a crucial component. The workshops proposed advocacy programs targeting key decision-makers at national and subnational levels. The success of One Health implementation depends on joint planning, development of policies, and program implementation in a multidisciplinary and multi-institutional framework.[13] Strengthening One Health governance across various administrative levels is also important for preventing and reducing potential zoonotic diseases. The review and revision of governance structures, combined with the development of a strategic framework and the establishment of One Health coordination units, are essential elements towards institutionalizing the One Health approach in Thailand. The One Health approach requires high-level commitments and advocacy from all sectors to build capacity and enhance the integrity and effectiveness of the One Health implementation. It also requires a clear definition of roles and responsibilities of the different sectors and details of existing coordination, which will help to strengthen coordination and collaboration and avoid unnecessary misunderstandings and misconceptions between the sectors.[8]

Enhancing joint surveillance is another issue that participants of the workshop discussed. Initiatives such as developing One Health guidelines, for example, for avian influenza surveillance, coupled with training programs for local officers, aimed to improve early detection and response to health threats. This system involves a multi-step process, including identifying triggering events, collecting samples from affected areas, conducting laboratory analysis, interpreting data, and coordinating response activities.[14] The robust surveillance framework has significantly enhanced intersectoral collaboration and data sharing, crucial for effectively managing zoonotic diseases. The development of operational SOPs for joint investigations has bridged critical gaps, ensuring rapid communication and coordination across all relevant sectors during outbreak responses, particularly in emergencies where resource sharing is essential.[15] The outcomes, including a detailed guidance document and a harmonized reporting system, have substantially strengthened Thailand's capacity to manage outbreaks.

Community engagement was also prioritized, with initiatives to involve village volunteers in risk communication and surveillance efforts. One important example of village health volunteers is to serve as an early warning active surveillance mechanism for any unusual poultry illnesses or deaths and influenza-like illnesses in the community.[16] These programs emphasize training local volunteers, equipping them with technical knowledge, and fostering community leadership. They empower local populations by involving them in surveillance, risk communication, and response efforts, thereby enhancing early detection and control of disease outbreaks. Furthermore, community participation ensures that health interventions are culturally appropriate and more likely to be accepted and sustained. Strengthening community engagement also builds local capacity and resilience, creating a robust network of informed individuals who can act promptly during health crises.

The perspectives from the IHR-PVS assessment in Thailand are consistent with global experiences in implementing the One Health approach. These activities are expected to enhance Thailand's preparedness for zoonotic diseases and contribute to supporting the development of a joint roadmap of corrective measures and strategic investments.[4] Moreover, a joint roadmap will also be included in the One Health Strategies and the National Action Plan for Health Security, which are the national action plans to ensure national capacities in health emergencies to achieve national, regional, and global efforts to strengthen health security and keep the world safe.

Limitations

This review paper is limited by its reliance on workshop discussion without audio recordings, which may have led to potential omissions or subjective interpretations of key points. Additionally, the findings are context-specific to Thailand and may not be fully generalizable to other settings with different health systems and governance structures.

Conclusion

The two national workshops on IHR and PVS provided a platform for Thailand to identify critical gaps in its One Health capacity and develop strategies to address them. Key findings highlighted the need for enhanced intersectoral collaboration, strengthened surveillance systems, improved risk communication, and effective community engagement. Policy recommendations from this review emphasize improving the understanding and implementation of the One Health approach among key multisectoral decision-makers. Strengthening collaboration and resource allocation in technical areas such as joint surveillance, investigation, and risk assessment will streamline responses to health emergencies. Furthermore, fostering sustained capacity-building efforts, including workforce development and enhanced risk communication, is essential for improving One Health integration and preparedness for zoonotic disease outbreaks. Ultimately, these efforts will enhance the country's resilience to health threats and promote sustainable health outcomes for both humans and animals.

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