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Investigation of an Influenza A(H3N2) Outbreak and Assessment of Vaccine Effectiveness at a Non-commissioned Officer Training Center, Saraburi Province, Thailand, 2025

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Abstract

On 13 Oct 2025, an influenza-like illness (ILI) outbreak was reported at a non-commissioned officer training center in Saraburi Province, Thailand. We investigated to verify the outbreak, describe epidemiological characteristics, identify risk factors and the causative agent, estimate vaccine effectiveness (VE), and implement control measures. We conducted a retrospective cohort study among 903 students and staff. A suspected case was defined by fever (body temperature ≥37.5 °C) or a history of fever, plus cough and at least one other related symptom (sore throat, rhinorrhea, myalgia, headache, fatigue, or dyspnea), with onset between 1–28 Oct 2025. Data were collected via an online questionnaire, and specimens were tested using real-time PCR. Poisson regression with robust error variance estimated adjusted risk ratios (ARR). Of 887 respondents (98.2%), 159 suspected cases (attack rate 17.9%) were identified. Influenza A(H3N2) was confirmed. The epidemic curve, peaking on 11 Oct 2025, was consistent with person-to-person transmission, and the basic reproduction number was estimated at 0.81–1.10. Significant risk factors included close contact with a patient (ARR 1.22; 95% confidence interval (CI) 1.06–1.42) and sharing personal items (ARR 1.20; 95% CI 1.06–1.36). Handwashing before meals was protective (ARR 0.80; 95% CI 0.72–0.89). The VE against clinical illness was 19.1% (95% CI -20.0%–43.9%). This outbreak was associated with personal hygiene-related risk factors. The VE was low and not statistically significant, which may be consistent with known vaccine limitations against A(H3N2) strains. The outbreak rapidly subsided following the implementation of public health control measures.

Keywords: influenza, vaccine effectiveness, non-commissioned officer training center

Introduction

Influenza is an acute infection caused by a segmented RNA virus.[1] Its genomic structure facilitates rapid antigenic drift and shift, necessitating continuous surveillance. The World Health Organization estimates 1 billion infections annually, resulting in 3–5 million severe cases and 290,000–650,000 deaths.[2,3]

Transmission occurs via respiratory droplets and aerosols, with an average incubation period of two days (range 1–4 days)[2,4,5] Viral shedding can begin one day before symptom onset and persist for 5–7 days. Clinical presentation involves abrupt fever and upper respiratory symptoms.[2,5] While mostly self-limiting, high-risk groups face severe, potentially fatal complications.[3]

Vaccine effectiveness (VE) varies seasonally based on the vaccine-virus antigenic match and host factors like age and immunocompetence. Systematic reviews estimate the pooled effectiveness of inactivated vaccines in healthy adults at approximately 59%.[6] Furthermore, VE may decline during the season (intra-season waning), particularly against A(H3N2) and B strains.[7]

In Thailand, influenza circulates year-round with a bimodal peak. Influenza activity in 2025 significantly exceeded the 5-year median; as of September, over 486,000 cases and 57 deaths were reported.[8] This surge elevates outbreak risks in congregate settings like training centers and military camps. Such environments facilitate rapid transmission due to high-density living, close-contact training, and stressors.[9,10]

In Thailand, the National Immunization Program provides free annual vaccinations to seven high-risk groups, such as pregnant women, young children, the elderly, and individuals with chronic diseases.[11] Organizations like the Royal Thai Army and Police also conduct campaigns to preserve workforce readiness. However, variable coverage and timing can leave some cohorts susceptible to infection during peak transmission periods.[12,13]

On 13 Oct 2025, a cluster of approximately 40 students with influenza-like illness (ILI) was reported at a non-commissioned officer (NCO) training center in Saraburi. Health authorities like Saraburi Hospital, Saraburi Provincial Health Office, the local Subdistrict Health Promoting Hospital, and the Office of Disease Prevention and Control Region 4 Saraburi, mobilized a joint Surveillance and Rapid Response Team (SRRT) to investigate the same day. The objectives were to verify the outbreak, describe epidemiological characteristics, identify risk factors and the causative agent, estimate vaccine effectiveness, and implement control measures.

Methods

Study Design, Setting, and Population

We conducted a retrospective cohort study, including both descriptive and analytical components, to describe epidemiological characteristics and identify risk factors at an NCO training center in Saraburi Province, Thailand. Located in the central region, Saraburi serves as a transportation gateway with high mobility. The study population comprised all students and staff, focusing on symptom onset between 1–28 Oct 2025.

Active Case Finding, Data Collection, and Case Definitions

We employed a two-phase data collection strategy using a self-administered online questionnaire (Google Forms).

Data included: (1) demographics (age, gender, dormitory and method of commute); (2) clinical history (symptoms, onset date, underlying conditions: chronic respiratory diseases, cardiovascular diseases, chronic kidney disease, neurovascular diseases, obesity, cancer, and diabetes); (3) exposure and risk behaviors (handwashing, masking, sharing personal items), sleep duration, and history of contact with sick individuals; and (4) vaccination and treatment (influenza vaccination history and oseltamivir usage).

Phase I; Initial mass screening (13–14 Oct 2025)

The SRRT conducted active case finding, requiring all students and staff to complete the questionnaire to establish baseline health and exposure history.

Phase II; Enhanced surveillance (13–28 Oct 2025)

Subsequently, we implemented enhanced surveillance with twice-daily (at 08:00 AM and 04:00 PM) screening for fever, respiratory symptoms, and oxygen saturation. Suspected cases completed the questionnaire. Active surveillance concluded on 28 Oct 2025 after exceeding the maximum incubation period with no new cases, though passive monitoring continued until the center's closure on 31 Oct 2025.

Data management

To address multiple submissions, we de-duplicated the dataset by retaining the most recent record per participant, ensuring the analysis captured the final disease status and symptom profile.

Case definitions

Cases were classified as follows: (1) suspected case—a student or staff member with a body temperature ≥37.5 °C or a history of fever, plus cough, and at least one of the following symptoms: myalgia, sore throat, rhinorrhea, headache, fatigue, or dyspnea, with onset between 1 Oct 2025 and 28 Oct 2025; (2) probable case—a suspected case that tested positive using an influenza rapid antigen test (RAT); (3) confirmed case—a suspected or probable case with laboratory confirmation of influenza virus infection by real-time polymerase chain reaction (RT-PCR) from a nasopharyngeal swab.

Laboratory Methods

Nasopharyngeal swabs were collected from suspected cases presenting to Saraburi Hospital with fever and cough. Specimens were screened by RAT; positive samples were sent to the Office of Disease Prevention and Control Region 4 Saraburi for RT-PCR subtype confirmation.

Data Analysis

Data were analyzed using R software, version 4.5.1 (R Core Team, Vienna, Austria).[14] We used *tidyverse* for manipulation and *gtsummary/flextable* for tables. Adjusted risk ratios (ARR) were calculated using multivariable Poisson regression with robust error variances (*sandwich* package). Statistical significance was defined as p-value <0.05.

Descriptive epidemiology

We analyzed data by person, place, and time using frequencies, percentages, and attack rates (AR). Person-level characteristics, risk behaviors, and symptoms were summarized. Time was visualized via an epidemic curve, and place by dormitory-stratified AR.

Analytical epidemiology

A retrospective cohort study was conducted to identify risk factors and estimate vaccine effectiveness.

- *Source population and sampling*

The source population comprised all students and staff residing at the center. Given the manageable population size, we employed a total enumeration (census) approach to invite all individuals, maximizing statistical power without sampling.

- *Variables*

Dependent variable: meeting the suspected case definition.

Independent variables included: (1) demographic characteristics and health (gender, age group, and presence of comorbidities); (2) method of commute to the center; (3) risk behaviors (handwashing, masking, sharing personal items, and sleep duration [5-point Likert scale]); (4) history of contact with sick individuals; (5) vaccination status.

- *Statistical analysis*

We calculated crude risk ratios (RR) with 95% confidence intervals (CIs) using Chi-square or Fisher's exact tests. Variables with p-value <0.1 were included in a multivariable Poisson regression model with robust error variances to estimate adjusted risk ratios (ARR). Vaccine effectiveness (VE) was calculated as VE=(1–RR) ×100 using crude RR, as vaccination status did not meet multivariable model inclusion criteria.

Estimation of Reproduction Number

To characterize transmissibility, we estimated: (1) Basic reproduction number (R_0) using the R_0 package via attack rate, exponential growth, and maximum likelihood methods for robustness; (2) Time-dependent effective reproduction number (R_t) to evaluate interventions, assuming a mean generation time of 3.2 days (SD 2.1).[15]

Environmental and Activity Assessment

In addition to the retrospective cohort study, we conducted an environmental walk-through of dormitories, the refectory, and training facilities to assess density, ventilation, and hygiene. Key staff were also interviewed regarding daily schedules and activities.

Results

Of 903 students and staff at the center, 887 (98.2%) participated. We identified 159 suspected cases (attack rate 17.9%). Most (96.9%) had mild-to-moderate symptoms and were managed on-site in isolation. Five (3.1%) severe cases (oxygen saturation <95%) were hospitalized. All responded well to treatment; no respiratory failure or deaths occurred.

Descriptive Epidemiology

All 159 cases were identified via active and enhanced surveillance. No cases were identified solely through passive reporting. All were male. The mean (standard deviation) age was 22.8 (2.96) years. The most affected age group was 21–25 years (52.8%). Regarding commuting methods, 80 (50.3%) traveled to the center either on foot, by bicycle, or in a private car, while 79 (49.7%) used public transportation. Four reported comorbidities (aggregated as binary due to low prevalence). Most (78.6%) had received the influenza vaccine after 1 Oct 2024. During their illness, 98 (61.6%) received oseltamivir treatment.

Common symptoms included rhinorrhea (87.4%), sore throat (86.8%), fatigue (65.4%), myalgia (60.4%), headache (55.4%), and dyspnea (28.9%).

Attack rates varied: Division 3 (21.8%), Division 2 (17.2%), and Division 1 (16.0%). Only one staff member was affected (Table 1).

The first case occurred on 1 Oct 2025; cases peaked on 11 Oct 2025, followed by a sharp decline from 13 Oct 2025 (Figure 1).

Table 1. Distribution of influenza cases and attack rates by population group, non-commissioned officer training center, Saraburi Province, Thailand, 1-28 Oct 2025

Population group	Total population	Number screened	Suspected cases	Probable cases	Confirmed cases	Total cases	Attack rate (%)
Division 1	290	287	46	0	0	46	16.03
Division 2	290	290	50	0	0	50	17.24
Division 3	290	284	59	0	3	62	21.83
Staff	33	26	1	0	0	1	3.85
Total	**903**	**887**	**156**	**0**	**3**	**159**	**17.93**

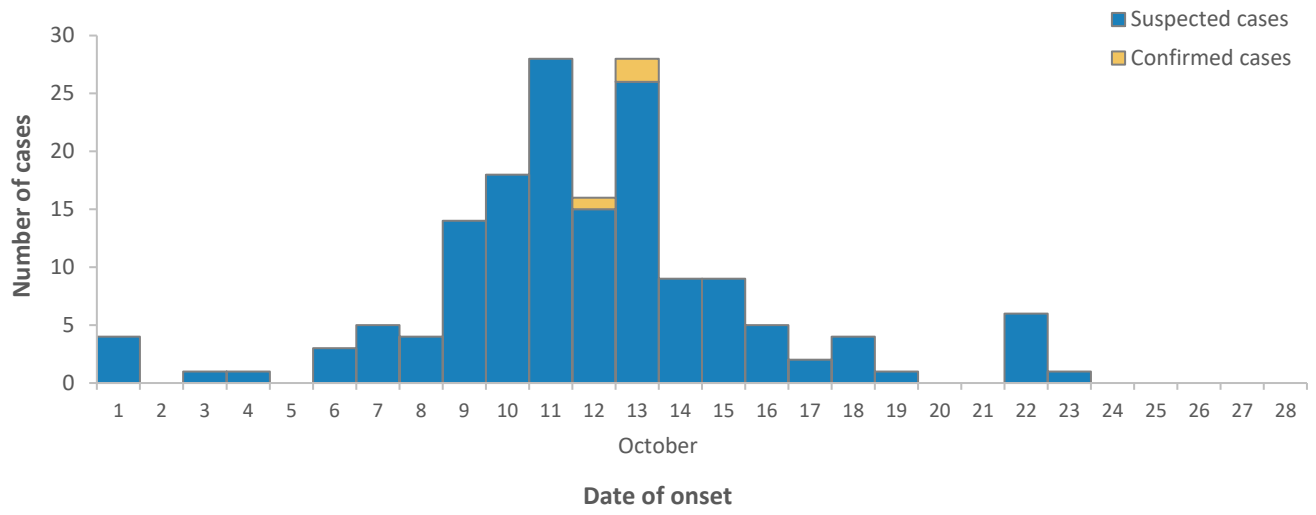

Figure 1. Epidemic curve of an influenza outbreak, non-commissioned officer training center, Saraburi Province, Thailand, 1–28 Oct 2025

Laboratory Findings

Of seven specimens collected, three were RAT-positive. Four underwent RT-PCR (including the three RAT-positives); three were confirmed as influenza A(H3N2) with cycle threshold values of 21.8–25.1. The single PCR-negative case had initiated oseltamivir prior to collection.

Analytical Epidemiology and Vaccine Effectiveness

Significant univariable factors included handwashing with soap and water before meals (p-value 0.012), close contact with patients (p-value <0.001), and sharing personal items (e.g., spoons, drinking glasses) (p-value <0.001) (Table 2).

Multivariable analysis identified three independent factors: handwashing with soap and water before meals (ARR 0.80, 95% CI 0.72–0.89, p-value <0.001), close contact with patients (ARR 1.22, 95% CI 1.06–1.42, p-value 0.011), and sharing personal items (ARR 1.20, 95% CI 1.06–1.36, p-value 0.008).

Vaccine effectiveness against suspected clinical illness was 19.1% (95% CI: –20.0% to 43.9%).

Reproduction Number

Estimated R_0 approximated 1.0 (attack rate 1.10, 95% CI 1.08–1.12; exponential growth 0.85, 95% CI 0.79–0.92; maximum likelihood 0.98, 95% CI 0.77–1.21). R_t peaked at 3.24 on 6 Oct 2025 (linked to a communal event) but dropped below 1.0 after 11 Oct 2025, coinciding with interventions and peak reporting (Figure 2).

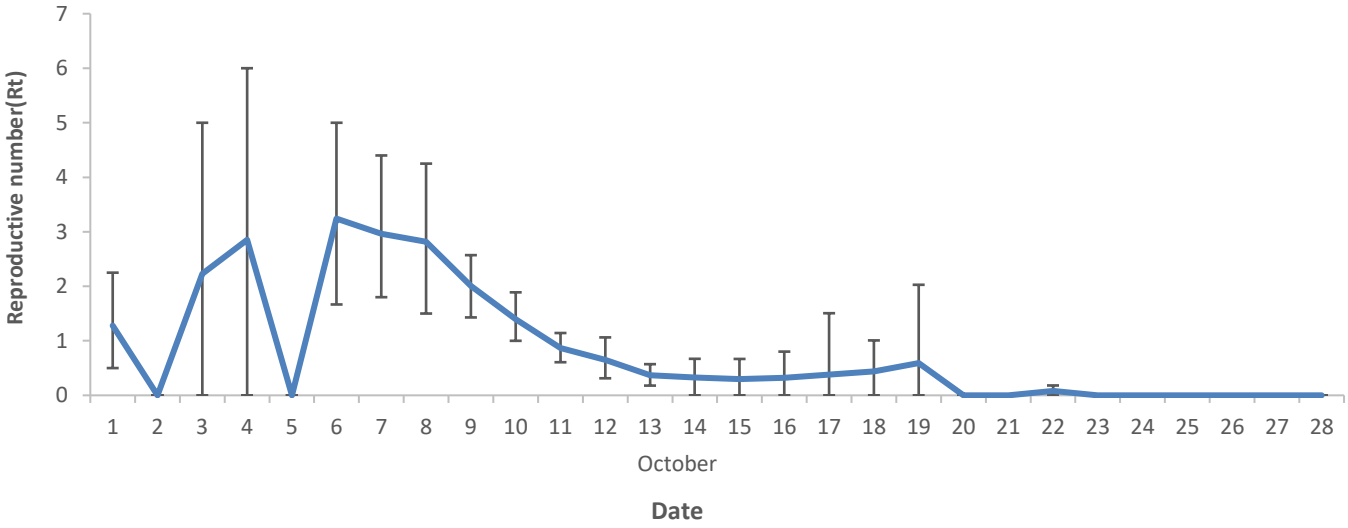

Figure 2. Time-dependent reproduction number (R_t) of the influenza outbreak, non-commissioned officer training center, Saraburi Province, Thailand, 1–28 Oct 2025

Table 2. Univariable and multivariable analysis of risk factors associated with influenza illness, non-commissioned officer training center, Saraburi Province, Thailand, 1-28 Oct 2025

Factor	Non-cases (%) (n=728)	Cases (%) (n=159)	Univariable analysis		Multivariable analysis	
			Relative risk (95% CI)	*P*-value	Adjusted RR (95% CI)	*P*-value
Gender						
Male	722 (81.95)	159 (18.05)	Ref	0.598	-	-
Female	6 (100.00)	0 (0.00)	Undefined			
Age group (years)						
0–15	0 (0.00)	0 (0.00)	Undefined	0.084*	0.90 (0.75–1.07)	0.312
16–20	176 (81.11)	41 (18.89)	Ref			
21–25	401 (82.68)	84 (17.32)	0.92 (0.64–1.34)			
26–30	121 (78.57)	33 (21.43)	1.13 (0.71–1.79)			
31–60	30 (96.77)	1 (3.23)	0.17 (0.01–0.78)			
≥60	0 (0.00)	0 (0.00)	Undefined			
Commute to center						
Walk/bicycle/private car	317 (79.85)	80 (20.15)	Ref	0.135	-	-
Public/shared transport	411 (83.88)	79 (16.12)	0.80 (0.59–1.09)			
At least 1 comorbidity						
Yes	8 (66.67)	4 (33.33)	Ref	0.244	-	-
No	720 (82.29)	155 (17.71)	0.53 (0.22–1.73)			
Influenza vaccination						
Unvaccinated	126 (78.75)	34 (21.25)	Ref	0.255	-	-
Vaccinated	602 (82.81)	125 (17.19)	0.81 (0.56–1.20)			
Handwashing before meals						
Never	42 (70.00)	18 (30.00)	Ref	0.012**	0.80 (0.72–0.89)	<0.001**
Rarely	82 (78.85)	22 (21.15)	0.71 (0.38–1.33)			
Sometimes	112 (76.19)	35 (23.81)	0.79 (0.46–1.43)			
Mostly	265 (84.39)	49 (15.61)	0.52 (0.31–0.92)			
Always	227 (86.64)	35 (13.36)	0.45 (0.26–0.80)			
Mask wearing						
Never	64 (80.00)	16 (20.00)	Ref	0.113	-	-
Rarely	107 (86.99)	16 (13.01)	0.65 (0.32–1.31)			
Sometimes	159 (80.71)	38 (19.29)	0.96 (0.55–1.78)			
Mostly	242 (84.91)	43 (15.09)	0.75 (0.43–1.35)			
Always	156 (77.23)	46 (22.77)	1.14 (0.66–2.07)			
Close contact with patient						
Never	113 (94.17)	7 (5.83)	Ref	<0.001**	1.22 (1.06–1.42)	0.011**
Rarely	112 (82.96)	23 (17.04)	2.92 (1.32–6.83)			
Sometimes	182 (85.45)	31 (14.55)	2.49 (1.17–6.17)			
Mostly	207 (80.54)	50 (19.46)	3.34 (1.62–8.07)			
Always	114 (70.37)	48 (29.63)	5.08 (2.46–12.3)			
Sharing personal items						
Never	254 (88.19)	34 (11.81)	Ref	<0.001**	1.20 (1.06–1.36)	0.008**
Rarely	93 (85.32)	16 (14.68)	1.24 (0.67–2.21)			
Sometimes	205 (83.00)	42 (17.00)	1.44 (0.92–2.28)			
Mostly	118 (76.13)	37 (23.87)	2.02 (1.27–3.23)			
Always	58 (65.91)	30 (34.09)	2.89 (1.76–4.72)			
Sleep 6-8 hours per day						
Never	9 (90.00)	1 (10.00)	Ref	0.519	-	-
Rarely	25 (80.65)	6 (19.35)	1.94 (0.33–36.6)			
Sometimes	71 (78.02)	20 (21.98)	2.20 (0.46–39.4)			
Mostly	213 (80.08)	53 (19.92)	1.99 (0.44–35.2)			
Always	410 (83.84)	79 (16.16)	1.62 (0.36–28.5)			

**p-value <0.1, **p-value <0.05. Multivariable results for ordinal variables (e.g., handwashing) are presented as a single adjusted risk ratio, representing the risk trend across categories, which were entered into the model as continuous ordinal variables. RR: relative risk. CI: confidence interval.*

Environmental and Activity Assessment

Environmental investigation revealed high transmission risks:

(1) Dormitories: trainees resided in long, two-story concrete buildings. Beds were arranged in two long rows. The spacing between adjacent beds was approximately 0.5 to 1.0 meters, indicating high physical proximity during sleep. Ventilation relied on large industrial fans, which, while reducing heat, likely facilitated the circulation of viral aerosols across the sleeping quarters.

(2) Refectory: the dining area had a seating capacity of 320, organized into tables of eight (four students facing four). This arrangement forced face-to-face interaction at close range (<1 meter) during meals. Furthermore, chairs were covered with fabric cloths (potential fomites), and food service staff were observed working without masks.

(3) Shared facilities: bathing facilities utilized a large communal water tub (dipping style), and water for handwashing sinks was available only during specific intervals, potentially hindering consistent hand hygiene.

(4) High-risk activities: the daily schedule (05:00 AM–09:00 PM) was strictly regimented. Key activities identified as high-risk included field training involving unmasked group exercises with loud vocalization. Two mass gathering events—the "welcome new students" (1 Oct 2025) and "senior-welcomes-junior" (6 Oct 2025)—coincided with the start of the outbreak.

Actions Taken

The SRRT implemented immediate enhanced surveillance with twice-daily screening by on-site nurses. Suspected cases were isolated. Clinical management followed a collaborative model: Saraburi Hospital physicians authorized oseltamivir, while center nurses managed daily care and monitoring.

Concurrently, the SRRT provided health education on symptoms and prevention via trainers and materials. Environmental measures included disinfecting high-touch surfaces.

Key non-pharmaceutical interventions (NPIs) included strict handwashing, mandatory masking for symptomatic cases (source control), and suspension of group activities. These measures continued until the center closed for term break on 31 Oct 2025.

Discussion

This investigation describes a rapid Influenza A(H3N2) outbreak in a high-density setting (attack rate 17.9%). This finding underscores the rapid transmission potential of influenza in such environments. This aligns with previous military and training centers studies (10–40%),[16] though lower than a 2017 military recruit unit in Chiang Mai report (40.8%).[17] While the AR in our study was lower, it confirms the profound vulnerability of this population. This vulnerability is likely driven by environmental and structural factors, such as high-density dormitories with closely arranged beds and a curriculum requiring continuous, close-contact group activities, which are highly conducive to the spread of respiratory droplets. The epidemic curve suggested propagated spread, with peaks coinciding with two major communal events that likely amplified transmission. Additionally, low cycle threshold values indicated high viral loads, further facilitating rapid spread.

Personal behaviors drove transmission. Close contact (ARR 1.22) and sharing items (ARR 1.20) were significant risks, inherently difficult to mitigate given structured training routines. Conversely, handwashing before meals was protective (ARR 0.80), aligning with evidence of 16–21% risk reduction.[18] Where physical distancing is operationally infeasible, reinforcing basic hygiene remains paramount.[19]

We observed a low, non-significant VE of 19.1% against clinical illness. This aligns with historical data showing reduced effectiveness for H3N2 (~33%), often attributed to rapid antigenic drift or egg-adaptive mutations during manufacturing. [20,21] Although the cohort received the 2025 Southern Hemisphere influenza vaccine approximately one month before the outbreak, we were unable to perform genetic sequencing or hemagglutination inhibition assays on the clinical specimens due to limited laboratory resources.[11] Therefore, while we strongly suspect antigenic drift or vaccine strain mismatch contributed to the low VE, this hypothesis remains presumptive and relies on the indirect evidence of the low clinical protection observed in this outbreak.

Despite the rapid spread of the outbreak, the R_0 ranged between 0.85 and 1.10. While R_0 is theoretically defined for a completely susceptible population, a large proportion of this cohort was vaccinated. Although vaccination coverage was high, the low VE implies that the vaccine conferred minimal protection. Consequently, the population remained functionally susceptible to this specific circulating A(H3N2) strain, validating the use of this estimate as an approximation of the virus's intrinsic transmission potential in this setting. This value is notably lower than the natural R_0 for seasonal influenza typically reported in congregate

military settings, which often ranges from 2.68 to 4.84.[22] The suppression of the overall R_0 to near unity likely reflects the impact of early behavioral adaptations and the prompt initiation of control measures, which dampened the average transmission potential over the course of the outbreak. However, the true intensity of transmission is better illustrated by the time-dependent effective reproduction number, which peaked at 3.24 during the early phase. This early peak raises the critical question of whether the subsequent decline in cases resulted from the population reaching the herd immunity threshold. Based on the peak R_t of 3.24, the theoretical herd immunity threshold is approximately 69% (calculated as $1–1/R_t$). Yet, the observed AR was only 17.9%, significantly below this threshold. This discrepancy strongly suggests that the outbreak did not burn out naturally due to the depletion of susceptible hosts. Instead, the rapid reduction in R_t to below 1.0 was driven by the effective implementation of public health interventions—specifically patient isolation and strict hygiene enforcement—which truncated the transmission chain.

This investigation highlights the limitation of relying solely on mass vaccination in congregate settings. While essential, high coverage proved insufficient against H3N2, a subtype prone to antigenic drift and lower effectiveness.[20,22] Sole reliance creates a "single-point failure" risk, permitting rapid transmission when VE declines—a phenomenon common in military cohorts.[16,17] Consequently, we advocate for a resilient "vaccine-plus" strategy.[23] This multi-layered approach integrates vaccination with pre-emptive NPIs (e.g., hygiene enforcement, density reduction) to mitigate risk when vaccine protection is suboptimal.[19]

Limitations

This study has several limitations. First, self-reported data introduces potential recall bias. Second, using a broad clinical case definition rather than lab confirmation risks non-differential misclassification (potentially capturing other pathogens), which typically biases associations toward the null. Third, prioritizing symptomatic testing missed asymptomatic infections, likely underestimating transmission. Furthermore, unaccounted prior natural immunity in unvaccinated controls could further bias VE estimates toward the null. Finally, the study was underpowered to detect low VE. With a fixed cohort (n=887) and few unvaccinated controls (n=34), the sample size was insufficient to statistically confirm the observed protection (post-hoc requirement: $n \approx 1,475$).

Recommendations

We propose recommendations for military and residential training institutions globally:

(1) Institutionalize hygiene as a discipline: Hygiene protocols must be integrated into core disciplinary curricula rather than treated as optional advice. Mandatory handwashing before meals and strict prohibition of sharing personal items (e.g., utensils) should be enforced as standard operating procedures.

(2) Adopt a "vaccine-plus" strategy: Authorities should shift from sole reliance on vaccination to a multi-layered approach. Given suboptimal H3N2 protection, policies must mandate pre-emptive NPIs—such as density reduction and ventilation improvements—before intake, regardless of vaccination status.

(3) Enhance surveillance: Future investigations involving low VE despite high coverage should prioritize advanced molecular characterization (sequencing and culture). This is crucial for confirming antigenic mismatch and directly informing national vaccine strain selection.

Conclusion

We confirmed an influenza A(H3N2) outbreak at a Saraburi NCO training center (159 cases; AR 17.9%; peak 11 Oct 2025). Close contact and sharing items were risk factors; handwashing was protective. VE was 19.1%. Although R_0 was 0.85–1.10, R_t peaked at 3.24 before dropping below 1.0 following interventions. This demonstrates that rapid public health response effectively controls outbreaks in high-risk settings despite low vaccine effectiveness.

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Author Contributions

Panupong Tantirat: Conceptualization, data curation, formal analysis, investigation, methodology, software, supervision, validation, visualization, writing—original draft, writing—review & editing. **Sitthanon Jamhom:** Data curation, investigation, project administration, resources. **Jiraporn Kruksomrong:** Investigation, project administration, resources.

Ethical Approval

This investigation was initiated and conducted by Thai public health authorities (Saraburi Provincial Health Office and Saraburi Hospital) as an emergency public health response to an acute outbreak. The activity meets the criteria for "public health surveillance," which is broadly recognized and formally defined under international guidelines (such as the U.S. Common Rule 45 CFR 46.102(l)(2)) as distinct from “human subjects research”.

The primary objectives of this activity were disease control, prevention, and public health situational awareness, not the generation of generalizable scientific knowledge. Therefore, as this activity constituted routine public health practice and not research, it was determined to be exempt from formal review and approval by an Institutional Review Board. The investigation was nonetheless conducted in accordance with all relevant ethical principles, including the Declaration of Helsinki. All data were fully anonymized prior to analysis to ensure patient confidentiality.

Informed Consent

Informed consent was obtained from all participants involved in the study.

Data Availability

The data that support the findings of this study are available on request from the corresponding author. The data are not publicly available due to privacy or ethical restrictions.

Conflicts of Interest

The authors declare no conflict of interest.

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This investigation received no specific grant from any funding agency in the public, commercial, or not-for-profit sectors. All activities were conducted as part of the routine public health duties and supported by the operational budgets of the authors’ affiliated institutions.

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

During the preparation of this work, the author(s) used Gemini (Google) to translate the manuscript from Thai to English, search for relevant literature, enhance textual clarity, and refine the language for a formal academic tone. The content produced by this tool was reviewed and edited by the author(s), who accept full responsibility for the final text.

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