AIRFLOW, BEHAVIORS AND DELAYED DETECTION: DRIVERS OF A COVID-19 OUTBREAK IN A THAI MILITARY RECRUIT TRAINING UNIT, MAY-JUNE 2025

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Abstract

Background: On May 6, 2025, the Epidemiology Unit of Phramongkutklao Hospital was notified of a probable COVID-19 outbreak among recruits and instructors at a recruit training unit in Samut Sakhon Province, Thailand. A joint field investigation was conducted in collaboration with the 11th Medical Unit, the Epidemiology Unit of Phramongkutklao Hospital, and the Armed Forces Research Institute of Medical Sciences (AFRIMS).

Objective: To confirm and characterize the COVID-19 outbreak, identify critical gaps in the existing protocol and transmission factors, and provide recommendations for control and prevention.

Methods: A retrospective cohort study was conducted from May 1 to June 3, 2025. Cases included individuals with at least two COVID-19–compatible symptoms, a positive antigen test kit (ATK) result, or laboratory confirmation by real-time RT-PCR. Structured interviews and standardized questionnaires collected exposure and behavior data. A walk-through survey assessed environmental conditions, including airflow, temperature, and humidity in the dormitory. Outbreak control measures, including cohorting based on ATK results, were documented.

Results: Among 114 personnel, 47 cases were identified (attack rate 41.2%), with 97.9% symptomatic. Of these, 95.7% had received prior COVID-19 vaccination. Common symptoms were sore throat, headache, and cough. The environmental assessment showed elevated temperatures, humidity, and west-to-east airflow, which correlated with higher attack rates in the eastern sleeping zones. Behavioral factors included shared drinking glasses and proximity during meals; sharing glasses showed the lowest p-value (adjusted OR = 1.99, 95% CI: 0.89–4.48). Delayed detection due to a lack of systematic screening facilitated transmission.

Conclusions: The outbreak was driven by multifactorial causes, including delayed detection and environmental and behavioral factors. Alignment between airflow and attack rates highlights the role of ventilation. Proactive surveillance, systematic ATK screening for all respiratory symptoms, and enforcement of physical distancing are recommended to prevent similar outbreaks in congregate military settings.

Keywords: COVID-19, outbreak investigation, military recruit training unit, airflow, delayed detection
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Introduction

Coronavirus disease 2019 (COVID-19) is an emerging infectious disease caused by the novel coronavirus SARS-CoV-2, first identified in Wuhan, China, in late 2019. The virus rapidly spread worldwide, prompting the World Health Organization (WHO) to declare a pandemic in March 2020.[1] COVID-19 is mainly transmitted through respiratory droplets and contact with contaminated surfaces, and its clinical manifestations range from asymptomatic infection to severe respiratory illness.[2]

COVID-19 outbreaks have been repeatedly reported in military settings worldwide[3, 4], reflecting the inherent vulnerability of these environments where personnel live, train, and work in close quarters. In Thailand, the recruit training program in this unit represents the first intake of 2025 (Batch 1/68). During this intake, newly enlisted recruits arrived on May 1, 2025, and were scheduled to undergo a six-week intensive training program. Although national COVID-19 incidence had been primarily controlled during the study period, cluster outbreaks continued to occur in settings with close contact, limited ventilation, and prolonged shared activities—conditions that facilitate SARS-CoV-2 transmission.[5] Such environments include schools, correctional facilities, hospitals, and military camps.

The COVID-19 situation in Thailand in 2025 showed a consistent nationwide transmission pattern, evident from the national and regional health zones down to the provincial level. Surveillance data indicated that the outbreaks occurred between weeks 18 and 26, coinciding with the start of the rainy season. In the recruit training unit investigated, transmission was observed during week 19, a finding that aligned with the outbreak timeline observed at both the national and regional levels.

Recruit training units concentrate large numbers of young adults in shared sleeping quarters, high-density living areas, and daily face-to-face training activities, including intensive physical exercise that increases respiratory droplet generation. Furthermore, environmental factors such as inadequate ventilation, suboptimal airflow patterns, and high humidity in dormitory settings play a crucial role in sustaining transmission, particularly for airborne pathogens. Previous outbreaks in Thai military or recruit settings have been documented but remain limited in scope, and little is known about the combined roles of environmental, behavioral, and occupational factors in shaping outbreak dynamics within these settings.[6, 7]

Therefore, this study aimed to investigate a COVID-19 outbreak in a recruit training unit in Samut Sakhon Province, Thailand. To confirm and characterize the COVID-19 outbreak, identify critical gaps in the existing protocol and transmission factors, and provide recommendations for control and prevention.

Methods

A descriptive and analytical epidemiological study was conducted to investigate the COVID-19 outbreak in a recruit training unit in Samut Sakhon Province from May 1 to June 3, 2025. All recruits, instructors, and staff were included in active case finding and were interviewed using standardized outbreak investigation questionnaires developed by the Epidemiology Unit of Phramongkutklao Hospital. Information collected included demographics, date of symptom onset, clinical manifestations, vaccination history, risk behaviors, and screening test results.

Case definition

Case definitions were based on the COVID-19 surveillance and reporting guidelines of the Department of Disease Control, Ministry of Public Health, Thailand.[8] Suspected cases were defined as individuals residing in the training unit who exhibited at least two of the following symptoms during May 1–June 3, 2025: fever, cough, runny nose/nasal congestion, sore throat, sputum production, diarrhea, myalgia, headache, dyspnea, or altered taste/smell. Probable cases were suspected cases with a positive ATK result. Confirmed cases were probable cases with a positive SARS-CoV-2 real-time RT-PCR result.

For the analytic study, participants who met the case definition included suspected, probable, and confirmed cases, as defined above. The comparison group comprised recruits, instructors, and staff who did not meet the case definition.

Data collection

Data were collected using standardized outbreak investigation questionnaires. The primary outcome of interest was COVID-19 infection, defined as suspected, probable, or confirmed cases according to the descriptive case definitions. Exposures of interest included sleeping near symptomatic patients, dining near persons with influenza-like illness (ILI), alcohol consumption, smoking, sharing drinking glasses, infrequent handwashing, and COVID-19 vaccination history.

Sample size

Based on previous reports of COVID-19 infection in recruit training units in Buriram Province, Thailand, with an estimated attack rate of 55%[9] and assuming a 5% margin of error and a 95% confidence level, the minimum sample size required for this study was 381 participants, including both recruits and instructors.

Statistical analysis

Attack rates were calculated according to demographic and unit-specific characteristics. Epidemic curves were constructed to describe temporal patterns and the duration of outbreaks. Descriptive statistics, including counts, percentages, means ± standard deviations, medians (range), attack rates, and graphical representations, were used. Univariable logistic regression was performed to estimate risk ratios (RRs), 95% confidence intervals (CIs), and p-values. Multiple logistic regression with backward stepwise selection was subsequently conducted to estimate adjusted ORs with 95% CIs and p-values. Data analysis was performed using SPSS version 29.

Laboratory investigation

Respiratory specimens were collected from all suspected cases using nasopharyngeal swabs for ATK screening. Additionally, nasopharyngeal swabs from at least 5% of eligible recruits and instructors, as well as environmental samples from patient dormitories (including bedding, water dispenser handles, and fan switches), were collected using Universal Transport Media (UTM) for SARS-CoV-2 detection by real-time RT-PCR at the Armed Forces Research Institute of Medical Sciences (AFRIMS). Cycle threshold (Ct) values <36 were considered positive.

Environmental assessment

A walk-through survey was conducted to evaluate environmental factors that could facilitate viral transmission. Dormitories, training rooms, shower rooms, toilets, and the mess hall were assessed. Air velocity, CO_2 levels, temperature, and relative humidity (%RH) were measured using a TSI Q-Trak 7575 equipped with a thermoanemometer and IAQ probes, in accordance with the Department of Health, Ministry of Public Health, Thailand's established standards.[10] Natural ventilation was further evaluated using a 30-minute smoke test with an incense stick.

Results

The overall timeline of the outbreak in the recruit training unit, which occurred during week 19 of 2025, was consistent with national and regional trends observed during the same period (**Figure 1**).

Before the COVID-19 outbreak, the recruit training unit lacked a direct COVID-19 screening protocol. However, the unit maintained a system to screen heatstroke symptoms by measuring body temperature daily before and after training. If a recruit developed a fever or fell ill, they were given medication at the infirmary beneath the unit but were sent back to the communal dormitory without being isolated. This existing protocol focused on heat-related illness and lacked adequate isolation procedures, contributing to delayed detection and transmission of COVID-19.

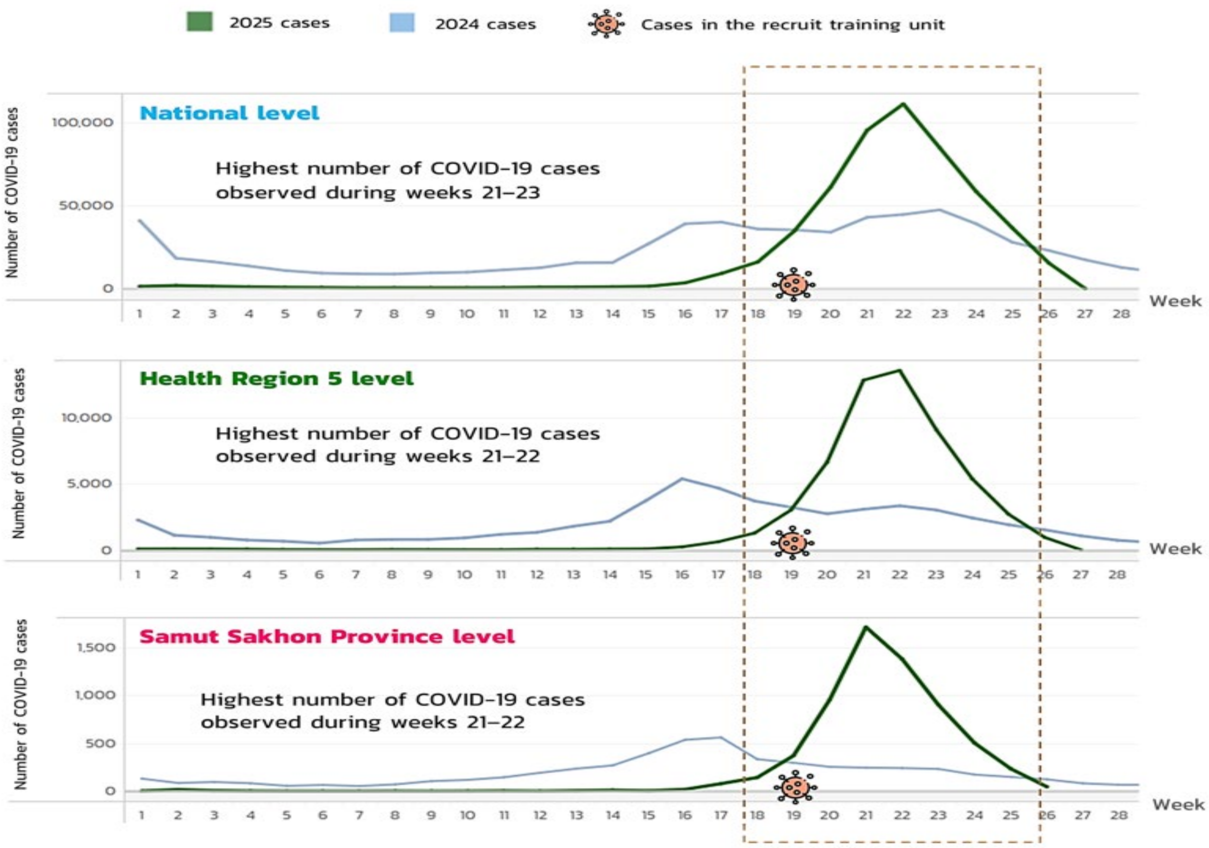

Figure 1. Comparison of the COVID-19 outbreak in 2025 across national, health region, and provincial levels (DDC Thailand, Digital Disease Surveillance, accessed Aug 15, 2025).[11]

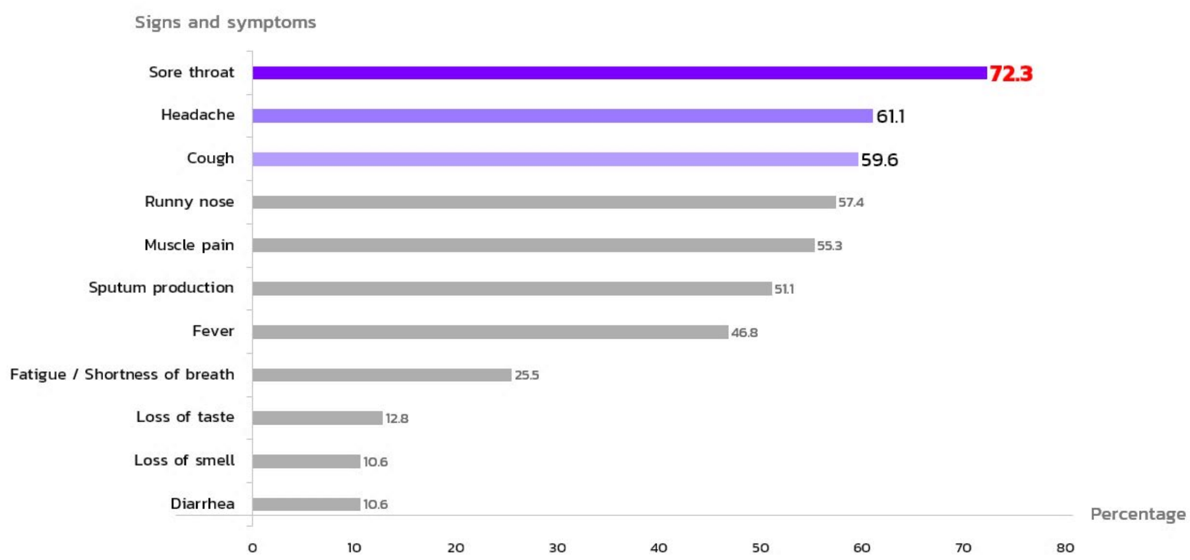

Figure 2. Percentages of signs and symptoms observed in COVID-19 patients in the recruit training unit, Samut Sakhon Province, from Apr 20 to May 7 2025 (n = 47).

In May 2025, a COVID-19 outbreak occurred among recruits at a recruit training unit in Samut Sakhon Province, Thailand. The unit consisted of 86 recruits, 13 recruit instructors, and 15 non-commissioned officer (NCO) instructors. No COVID-19 screening was conducted before entry. On May 5, one recruit (index case) developed a fever, followed by three additional recruits and one recruit instructor. All five cases were confirmed positive by ATK. Following the identification of these initial cases, a joint outbreak investigation team initiated mass screening of all personnel in the unit. This screening subsequently identified 42 additional positive cases, including 35 recruits, three recruit instructors, and four NCO instructors. In total, 47 cases were identified and included in the cohort analysis.

Descriptive epidemiology: person, time, and place

Of 114 personnel in this recruit training unit, 47 COVID-19 cases were identified (attack rate = 41.2%), including 44 probable cases and three confirmed cases; no suspected cases met the case definition. All 47 cases were male. Among these, 44 of 47 cases (87.4%) were aged 15–24 years, and 3 of 47 cases (12.6%) were aged 25 or older. By occupational position, 39 of 86 recruits (45.3%), 4 of 13 recruit instructors (30.8%), and 4 of 15 NCO instructors (26.7%) were infected. Regarding educational level, most cases had completed upper secondary education, accounting for 72.2%. Among these cases, 45 individuals (95.7%) had been vaccinated, while two individuals (4.3%) had not received the vaccine. The three most common signs and symptoms among COVID-19 cases in the recruit training unit were sore throat (72.3%), headache (61.1%), and cough (59.6%). Fever ranked sixth, observed in 46.8% of cases, as shown in **Figure 2.** Among the 47 identified cases, 46 individuals (97.9%) were symptomatic, while 1 (2.1%) was asymptomatic.

The COVID-19 outbreak in the recruit training unit was first identified on May 2, 2025, and the last symptomatic case occurred on May 7, 2025. The outbreak exhibited a point-source pattern, with a sharp peak in cases on May 5–6, 2025. Based on the epidemic curve stratified by occupation (**Figure 3**), recruits were the first group to show symptoms (outliers on April 20, 24, and 27), indicating they were the likely primary source of infection entering the central unit. The outbreak investigation was conducted on May 7, 2025. The estimated exposure period, based on the central cluster, was April 23–30, 2025.

Considering the spatial distribution of cases, the unit was divided into two dormitories. The dormitory-specific attack rates were 14 of 28 personnel (50.0%) in the small dormitory and 28 of 72 (38.9%) in the large dormitory. Stratified by sleeping zone, attack rates were consistently higher in the eastern zones for both dormitories: 8 of 14 (57.1%) in the east vs. 6 of 14 (42.9%) in the west for the small dormitory, and 15 of 36 (41.7%) in the east vs. 13 of 36 (36.1%) in the west for the large dormitory (**Figure 4**). Environmental monitoring indicated high relative humidity, particularly during nighttime rest periods. The average relative humidity across all dormitory points ranged between 69.0% and 71.0% at night. This combination of consistently higher attack rates in the downwind (eastern) zones and suboptimal environmental conditions provides evidence for a role of aerosol transmission in this high-density indoor setting.

Laboratory results

Between May 6 and 7, 2025, 114 individuals were screened for COVID-19 using ATK, of whom 47 tested positive. On May 9, 2025, nasopharyngeal swab specimens were collected from three suspected cases (two recruits and one instructor, 6.4% of all cases) for confirmation of SARS-CoV-2 infection by real-time RT-PCR, and all specimens tested positive. In addition, three environmental samples were collected from patient accommodation areas, including bedding, water dispenser handles, and fan switches, for detection of SARS-CoV-2 genetic material by real-time RT-PCR. All samples tested negative (**Table 1**).

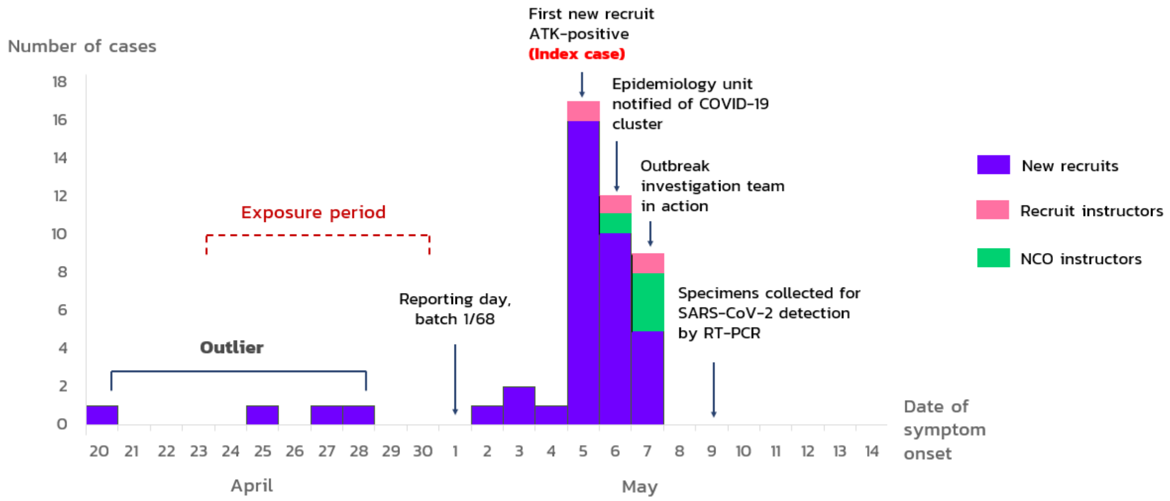

Figure 3. Epidemic curve of a COVID-19 cluster in the recruit training unit, Samut Sakhon, stratified by occupation, Apr 20–May 7 2025 (n = 47).

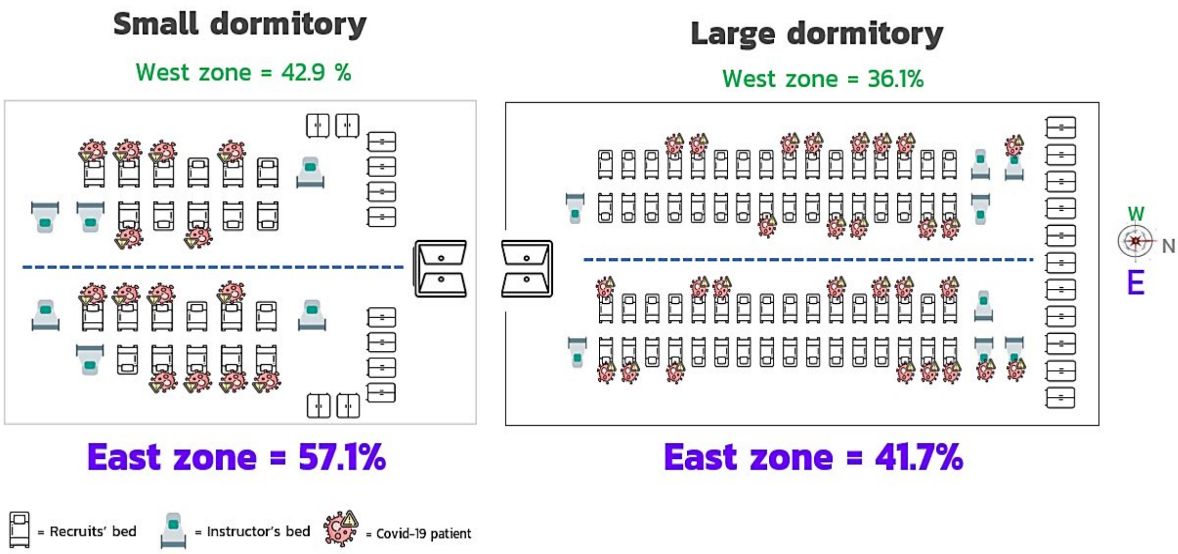

Figure 4. COVID-19 patient bed layout and zone-specific attack rates of recruits and instructors, Samut Sakhon (n = 114).

Analytic study

The analytic study included 103 personnel who were available for data collection at the time of investigation; the 11 non-commissioned officers who were excluded were on duty at other units. Based on the case definition, 47 participants met it, while the remaining 56 did not and served as the comparison group in the analytic study. Univariable logistic regression analysis (**Table 2**) showed that none of the variables were significantly associated with COVID-19 occurrences. However, sharing a drinking glass with others within the company had the lowest *p*-value among all variables. In the multivariable logistic regression analysis examining the association between risk factors and COVID-19 (**Table 3**), the adjusted odds ratio (OR) for individuals sharing a drinking glass compared with those not sharing was 1.99 (95% CI: 0.89–4.48, although this association was not statistically significant.

Environmental study

The dormitory

Both dormitories were enclosed with second-floor rooms with natural ventilation through

Table 1. Laboratory findings of SARS-CoV-2 detection categorized by sample type

Sample	Ct value			Result
	ORF1ab gene	N gene	E gene	
Instructor	31.67	27.14	31.41	Detected*
Recruit A44	27.35	23.58	28.48	Detected*
Recruit B47	32.87	27.84	32.20	Detected*
Bedding	0.00	0.00	0.00	Not Detected
Water dispenser handles	0.00	0.00	0.00	Not Detected
Fan switches	0.00	0.00	0.00	Not Detected

*Detected: Ct value < 36

Table 2. Univariable logistic regression analysis of risk factors associated with COVID-19 (n = 103)

Risk factor	Exposed group		Non-exposed group		RR	95%CI	*p*-value
	COVID-19	No COVID-19	COVID-19	No COVID-19			
1. Close contact with infected individuals							
Sleeping near symptomatic patients	8	11	39	45	0.93	0.60-1.43	0.802
Dining near persons with ILI	9	7	38	49	1.29	0.72-2.31	0.419
2. Health status							
Alcohol consumption within the past 30 days	11	20	36	36	0.78	0.55-1.10	0.201
Smoking	26	33	21	23	0.93	0.65-1.34	0.842
3. Personal hygiene							
Sharing drinking glasses	22	17	25	39	1.4	0.93-2.10	0.105
Infrequent handwashing	5	5	42	51	1.1	0.57-2.09	1
4. Vaccination history							
Received COVID-19 vaccine	43	54	4	2	0.67	0.36-1.22	0.408

RR = Relative Risk, CI = Confidence Interval

Table 3. Multivariable analysis of the association between risk factors and COVID-19 (n=103)

Risk factor	Crude RR (95% CI)	Crude OR (95% CI)	Adjusted OR (95% CI)	*p*-value
1. Close contact with infected individuals				
Dining near persons with ILI	1.29 (0.72-2.31)	1.66 (0.57-4.86)	1.60 (0.54-4.77)	0.397
2. Personal hygiene				
Sharing drinking glasses	1.40 (0.93-2.10)	2.02 (0.90-4.52)	1.99 (0.89-4.48)	0.096

RR = Relative Risk, OR = Odds ratio, CI = Confidence Interval

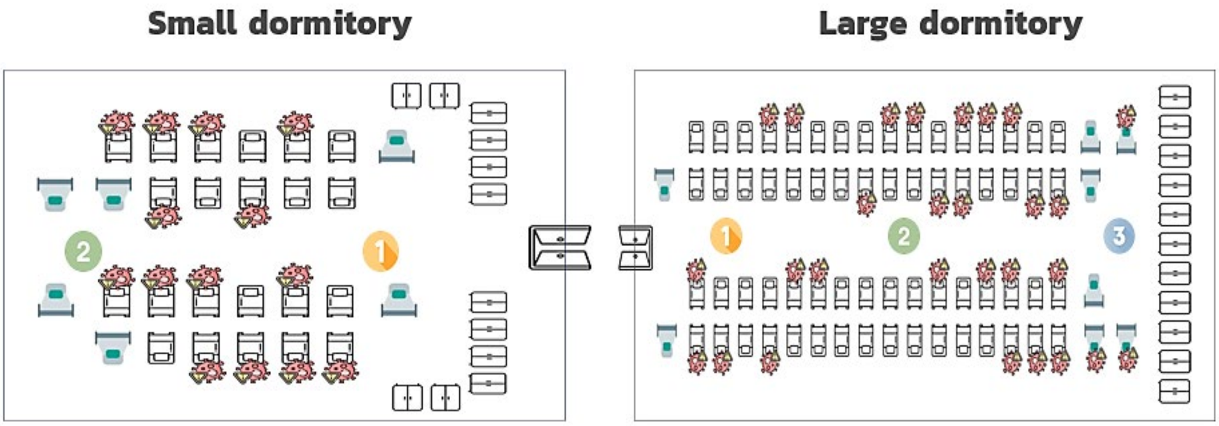

Figure 5. Layout of sleeping arrangements for recruits and instructors at the recruit training unit, Samut Sakhon Province. Numbers 1, 2, and 3 indicate points of environmental parameter measurements.

open windows and louvered vents. The smaller dormitory on the left contained 28 beds in a 15×10 m area (5.36 m² per person), while the larger dormitory on the right contained 72 beds in a 35×10 m area (4.86 m² per person). Although floor space exceeded the non-crowded standard (>4 m² per person), bed spacing within rows remained relatively close (**Figure 5**). Smoke testing indicated prevailing airflow from west to east. Environmental measurements showed that temperature and relative humidity exceeded recommended levels, particularly at night, potentially supporting viral survival (**Table 4**).

Training room

The training room was located on the first floor of the recruit training unit building, with ceiling fans and portable fans installed, and surrounding trees blocking direct sunlight. Before the COVID-19 outbreak, recruits were seated in an orderly manner, with a distance of less than 1 meter between chairs and no masks worn. Environmental measurements indicated that both temperature and relative humidity exceeded recommended levels during the day and at night (**Table 4**).

Mess hall

The mess hall was a single-story concrete building with screened windows providing natural ventilation and daylight. Inside, 24 tables accommodated the recruits, with duty soldiers placing pre-portioned meals on trays. Recruits could refill their trays if they are still hungry. Before the COVID-19 outbreak, four recruits shared each table without partitions, using personal cutlery that was washed and stored after meals. Drinking water was obtained from a refill station at the entrance using personal bottles. After the outbreak, meals were distributed as prepackaged boxed lunches.

Table 4. Environmental indicators in dormitories and training room of recruits by day and night.

Location	Indicator	Daytime	Nighttime
Small dormitory point 1	Air velocity (m/s)	0.1	0.3
	CO_2 level (ppm)	420	450
	Temperature (°C)	33.2	31.0
	Relative humidity (%)	68.0	70.0
Small dormitory point 2	Air velocity (m/s)	0.5	0.7
	CO_2 level (ppm)	420	410
	Temperature (°C)	33.0	30.9
	Relative humidity (%)	67.0	69.0
Large dormitory point 1	Air velocity (m/s)	0.1	0.5
	CO_2 level (ppm)	470	390
	Temperature (°C)	33.5	31.0
	Relative humidity (%)	67.0	70.1
Large dormitory point 2	Air velocity (m/s)	0.1	0.7
	CO_2 level (ppm)	400	410
	Temperature (°C)	33.4	30.9
	Relative humidity (%)	66.0	70.3
Large dormitory point 3	Air velocity (m/s)	0.2	0.3
	CO_2 level (ppm)	430	400
	Temperature (°C)	33.0	30.7
	Relative humidity (%)	65.0	71.0
Training Room	Air velocity (m/s)	0.2	0.5
	CO_2 level (ppm)	390	410
	Temperature (°C)	33.0	31.0
	Relative humidity (%)	63.0	69.5

Shower and toilet facilities

The shower area was outdoors and contained four bathing basins, with each recruit using their own bathing equipment. Before the COVID-19 outbreak, showers were scheduled by platoon, with about 20 recruits per platoon. The toilets were inside a building with louvered vents that had accumulated dust, reducing ventilation and increasing humidity. Before the outbreak, approximately 15–20 recruits used the facilities simultaneously. Following the outbreak, measures were implemented to limit usage to 8–10 people at a time, establish temporary shower areas with partitions for patients, and provide separate toilets for patients. In contrast, usage for other recruits was restricted to no more than 10 individuals at a time.

Action taken

Cohorting based on ATK test results was immediately implemented. The small dormitory was designated for recruits who tested positive, while the large dormitory accommodated those with negative results. In both buildings, beds were appropriately spaced, and ventilation was improved in accordance with the environmental assessment findings. Recruits and instructors presenting with influenza-like illness were temporarily separated from the general training group for at least 7 days, or until symptoms were resolved and an ATK result was negative. Furthermore, comprehensive infection prevention measures were provided to all personnel, including wearing face masks at all times, performing hand hygiene after daily activities, avoiding the sharing of personal items (e.g., drinking cups, towels, and bedding), drinking only from individual water bottles, avoiding close contact for 7 days after symptom onset, and regularly cleaning bedding and frequently touched surfaces.

Discussion

This comprehensive outbreak investigation, which included a retrospective cohort study component, confirmed a high overall attack rate of 41.2% among personnel in the recruit training unit, primarily driven by recruits. The outbreak described here shares similarities with previous events in military settings. The outbreak in Buriram Province reported a higher attack rate of 55.5% due to larger group housing and delays in isolating symptomatic cases.[9] In comparison, a special operations unit in Narathiwat Province reported a lower attack rate of 19.7% owing to predominantly outdoor activities and rapid isolation.[12] The novel contribution of this study is the ability to link qualitative environmental evidence with spatial epidemiological findings directly. Specifically, the observed higher attack rates in the eastern sleeping zones of both dormitories were directly consistent with the prevailing natural airflow direction (west to east) indicated by smoke tests. This finding provides strong inferential evidence supporting aerosol or airborne transmission as a key driver of the outbreak in this high-density indoor setting.

The most significant factor contributing to the rapid transmission was the failure of existing protocols to detect and isolate early cases. Crucially, the unit's pre-existing protocol, which focused solely on heatstroke screening by monitoring temperature but lacked any provision for isolating ill personnel, was a major system failure that delayed effective case management. This system failure, compounded by the mild symptom profile (low fever rate) and the tendency among unit personnel to underestimate the situation, meant that the initial symptomatic recruits were not isolated, effectively turning the dormitory into a propagation setting.

Environmental factors, particularly airflow and density, were critical. Airflow direction is known to affect pathogen transmission, especially for diseases spread primarily via respiratory droplets such as COVID-19 and influenza.[13] The correlation between west-to-east airflow and higher attack rates in the eastern zones strongly suggests that the natural ventilation system facilitated the movement of infectious aerosols across the sleeping quarters. The low measured air velocity (0.1–0.3 m/s in some areas) further indicated inadequate air exchange to dilute infectious aerosols quickly. Furthermore, environmental measurements showed elevated temperatures and relative humidity above recommended thresholds. Relative humidity above 65% is known to prolong viral survival and enhance airborne persistence in enclosed or poorly ventilated spaces.[14-16] These conditions were consistently observed, potentially increasing the risk of transmission during nighttime rest periods when personal protective measures were absent.

The WHO's physical distancing recommendations (>1 meter)[17] were not met during routine activities. Specifically, close contact was maintained during classroom seating, dining, military activities (e.g., buddy system), and crowded bathroom use, thereby increasing the likelihood of transmission. Behavioral practices, especially the sharing of drinking glasses, may have facilitated disease transmission. Although not statistically significant, this risk factor showed the lowest p-value and has been identified as a plausible transmission route in respiratory infections.[18]

Although the analytic study did not demonstrate statistically significant associations beween specific behaviors and COVID-19 infection, this finding should be interpreted with caution. The primary explanation for these null findings is the severe underpowering of the analytic study. The required minimum sample size to detect associations was calculated as 381 participants; however, the study included only 103 personnel, substantially reducing statistical power. This limitation, combined with the homogeneity of exposure and potential recall bias, likely masked any true behavioral risk factors. No viral genetic material was detected in environmental samples. Given that SARS-CoV-2 can survive for up to 3 days on smooth surfaces but behaves differently on absorbent materials,[19, 20] the negative results likely reflect delays in sample collection and cleaning measures already implemented. Vaccination history also appeared to influence clinical presentation: most personnel had received prior COVID-19 vaccination, and fever ranked only sixth among reported symptoms, consistent with the finding that vaccinated individuals often exhibit milder symptoms.[21]

Limitations of this study include insufficient statistical power, potential recall bias, social desirability bias (as junior personnel may have modified responses to align with expectations of higher-ranking interviewers), and the tendency of recruits to downplay symptoms, which contributed to delayed detection.

Recommendations include early ATK screening for all individuals with upper respiratory symptoms, even without fever; prompt isolation of patients (preferably placing them downwind when separate rooms are unavailable); prohibition of sharing personal items, with emphasis on individual drinking bottles; timely environmental sampling within 24–48 hours, focusing on frequently touched surfaces; and keeping patient-occupied rooms unused for at least three days before re-entry.

Conclusions

This COVID-19 outbreak in a military recruit training unit highlights the combined influence of behavioral, environmental, and operational factors on SARS-CoV-2 transmission in a high-density setting. Transmission was likely driven by shared personal items, delayed detection due to the absence of a structured screening system, close-proximity routine activities, and environmental conditions that favored aerosol spread. The consistent alignment between airflow direction and spatial attack-rate patterns underscores the importance of ventilation in enclosed group living quarters. To prevent similar events, military training units should implement proactive surveillance, establish systematic screening with prompt ATK testing for all individuals with respiratory symptoms (even in the absence of fever), reinforce personal hygiene practices, ensure adequate ventilation, and maintain feasible physical distancing during daily operations. These measures are essential for reducing transmission risk in congregate military environments.

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Declaration of Interests

All co-authors have completed disclosure of interest forms and have no conflicts of interest to declare.

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