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Editorial

COVID-19 Is Not Yet Over

Wiwat Rojanapithayakorn, Chief Editor

On 5 May 2023, the Director-General of World Health Organization declared that "the coronavirus disease (COVID-19) is now an established and ongoing health issue which no longer constitutes a public health emergency of international concern (PHEIC); and it is time to transition to long-term management of the COVID-19 pandemic". This declaration ended the over 3-year period since the PHEIC announcement on 30 Jan 2020. The disease which has become pandemic since 11 Mar 2020 has caused over 765 million confirmed cases and over 6.9 million deaths (as of 10 May 2023). This huge number of infected cases brings the disease to become the leading cause of infections of a pandemic in the past 100 years. Although the cumulative number of deaths is much lower than that of AIDS (estimated to be over 35 million), COVID-19 has caused much higher magnitude of negative socio-economic and health consequences to the world. The disease affected almost all sectors in the society of most countries as evidenced by massive social disturbance such as the disruption of population mobility, particularly the air transportation; closure of various social functions including schools, hotels, markets, shopping centers, industrial workplaces and many others, resulting in the negative economic growth; not to mention about the extremely high cost for the prevention and control.

Emergence of COVID-19 has altered the belief that infectious diseases were no longer important health problems as almost all severe communicable diseases in the past were effectively controlled by the use of antibiotics, vaccines and other prevention and control interventions. In most countries, national bodies responsible for communicable disease control were reformed to prioritize on the more common non-communicable diseases. COVID-19 pandemic is a warning sign that complacency on communicable disease control can be a dangerous issue in the public health system. Epidemiology for communicable diseases continues to be important subject to be strengthened in parallel with the epidemiology of non-communicable diseases.

On the positive side of the COVID-19 pandemic, the disease has provided numerous opportunities for research in public health. Most leading journals are supplied with all aspects of studies on the disease, ranging from outbreak investigation, prevention, clinical manifestations, therapeutic intervention including antiviral choices, hospital management, prevention and therapeutic vaccines, etc. The studies and reports on post-COVID conditions are also common. The recent ending of PHEIC for COVID-19 does not mean the pandemic is over. Many countries continue to report sporadic outbreaks, particularly among high risk population groups. Thus, epidemiological studies on COVID-19 remain a high priority for the control. The essential research areas include: (1) risk assessment in general and for some population subsets (non-vaccinated, people with chronic diseases, children and aged population), (2) investigations of new outbreaks, (3) necessity for practicing prevention (distancing, mask, hand washing, etc.), (4) effective treatment regimens, (5) effective innovations for different setting (workplace, prisons, educational institutions), (6) viral studies on contagiousness, severity, susceptibility to vaccine, etc., (7) studies on new vaccines and long-term side effects, (8) long-term manifestations of COVID-19 illness, (9) innovations and interventions at provincial and local levels, and (10) overall disease prevention and management interventions. These areas are just some outstanding examples. There are many more to be explored. One important matter is to make sure that the findings and knowledge of these studies are utilized for the prevention and control of the disease and be applicable for more emerging infectious diseases to come.

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Healthcare-associated Transmission of Lassa Fever, Sierra Leone, November 2019–January 2020

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Abstract

On 20 Nov 2019 the Tonkolili District Health Office was notified that a physician working in the district hospital was diagnosed with Lassa Fever (LF). The Tonkolili District had its last LF case in 2012. An investigation was performed to determine mode of transmission, magnitude and scope of this outbreak. Clinical information, exposure history, and blood samples were collected. Active case search and Infection Prevention and Control (IPC) assessment were conducted in the hospital and community. Three of five people with symptoms compatible with LF were polymerase chain reaction positive. The primary case, a pregnant woman from the community, was admitted with severe bleeding and operated by two surgeons and anesthetist. The same medical staff operated on another woman later that day. Three of the five cases died. The hospital assessment revealed non-adherence to IPC procedures. The primary case's residence had unhygienic conditions and inappropriate food storage. Low index of suspicion for LF and non-compliance to IPC procedures contributed to the associated healthcare workers' infection spread. Health workers were sensitized to LF and trained on IPC. Education of the community in high-risk areas about LF recognition, transmission and ways to decrease rodent populations in and around their homes is recommended.

Keywords: Lassa fever, investigation, outbreak, Tonkolili, Sierra Leone, healthcare

Introduction

Lassa fever is a viral hemorrhagic disease which begins as a flu-like illness, including fever, cough, sore throat, and joint, back, and chest pain. These symptoms resemble malaria, typhoid, dengue, yellow fever, and other viral hemorrhagic fevers, making clinical diagnosis difficult. The disease has an incubation period of 6–21 days.[1]

Lassa fever is endemic to West Africa, with more than 150 confirmed cases reported yearly in Sierra Leone.[2] The disease was first identified in Sierra Leone in 1970 during an outbreak in a hospital in an Eastern Province. At that time, the highest infection rate of Lassa fever in the world was in the Eastern Province.[3] The multimammate rats, mostly found in the West, Central, and East Africa, are the natural hosts of the Lassa fever virus.[2] Transmission from rodent to human can occur through inhalation of aerosols or by direct contact with rodent fluids such as urine, saliva, and feces, or indirectly through touching objects, food, or surfaces contaminated with rodent fluids.[1,4,5] Consumption of rodents has also been reported as a possible risk factor for Lassa fever transmission.[6,7] Secondary human-to-human transmission occurs through exposure to human bodily fluids in households or healthcare settings.[8,9] Poor infection prevention practices such as hand hygiene, use of personal protective equipment, and environmental cleaning are contributing factors in the transmission of Lassa fever among health care workers.[9]

The last confirmed case of Lassa fever in the Tonkolili District in the Northern Province of Sierra Leone was reported in 2012.[5] On 20 Nov 2019, the Tonkolili District Medical Officer alerted the district surveillance team that an expatriate surgeon working in a Tonkolili District Hospital tested positive for Lassa fever after being evacuated to his home country in Europe. The surgeon had fever, headache, and malaise before he was evacuated. On 21 Nov 2019, trainees from the Sierra Leone Field Epidemiology Training Program began their investigation of this event to identify sources of infection, the scope of the outbreak, assess Infection Prevention and Control (IPC) practices of the hospital, and improve the awareness of the community and health care workers to detect patients with Lassa fever and prevent further transmission. The findings may improve early detection of Lassa fever as well as improve case management, and ultimately reduce Lassa fever case fatality in Sierra Leone and other similar settings.

Methods

Study Area

The Lassa fever outbreak occurred in a hospital in the Tonkolili District in Sierra Leone. The district had a population of 530,000 in 2015.[6] There are 106 healthcare facilities consisting of three hospitals and 103 primary healthcare units feeding into the hospitals. The district is a mining area predominantly covered by forests and jungles and rodents are commonly found and eaten.

Study Design, Sample Collection, and Analysis

A descriptive cross-sectional study was designed to investigate the Lassa fever outbreak in the Tonkolili District, Sierra Leone. A suspected case was a person residing in the Tonkolili District who presented with a fever above 38 °C and did not respond to appropriate antimalarial and antibiotic treatment within 72 hours between 1 Nov 2019 and 31 Jan 2020. A probable case was any suspected case with epidemiological links to a confirmed Lassa fever case, or any patient in which clinicians suspected Lassa fever. A confirmed case was any suspected or probable case confirmed positive for Lassa fever IgM by enzyme-linked immunosorbent assay (ELISA) or by real-time polymerase chain reaction (RT-PCR). A contact was anyone who had physical contact, including handshaking, eating together, sleeping together, providing medical care, or having contact with body fluids of a confirmed or probable case from two weeks before symptoms onset to eight weeks after symptom onset.

Additional cases were searched for in the hospital and the cases' community. For cases in the hospital, medical records were obtained for patients admitted between 1 Nov 2019 and 31 Jan 2020 with fever above 38 °C who did not respond to appropriate antimalarial and antibiotic treatment within 72 hours. Clinicians and nurses were also interviewed to identify suspected cases. For cases in the community, cases' houses were visited and all household members were interviewed. In addition, key informants in the village (i.e., village and religious leaders) and community health workers were interviewed.

All contacts of the probable or confirmed cases were interviewed using a semi-structured questionnaire with closed and open-ended questions. The questionnaire collected demographic, clinical, and risk factors data. Blood samples were collected from all suspected or probable cases and the samples were sent for confirmatory testing, IgM ELISA test and PCR, at the Viral Hemorrhagic Fever Reference Laboratory in Kenema District.

Infection Prevention and Control Assessments in the Hospital

Compliance with IPC measures were assessed at the Tonkolili health facility by observing protocols and practices for sterilization and decontamination of the surgical equipment and medical supplies used to operate on the primary case of this outbreak. A standard IPC assessment checklist was used to observe the availability of hand washing points with running water and soap, and use of personal protective equipment (PPE) such as gowns, gloves, facemasks, and face shields. The medical staff were also interviewed to determine if they followed proper handwashing practices, and use of gowns, gloves, face masks, and face shields. However, the IPC self-reported practices were assessed among healthcare workers who were involved in the management and care of the two probable cases. The general environment was observed for hygiene including environmental cleaning inside and outside of the hospital's operating room.

Environmental Assessment at the Cases' Residence

The house of the primary case was assessed and inspected for hygienic conditions and rodent infestation. Storage collection, and disposal of trash and garbage were also observed.

Data Analysis

The demographic, clinical, and exposure data was described for each case-patient identified during the investigation. A pictorial diagram was used to summarize the clinical and epidemiological history of each case-patient, i.e., the history from date of exposure to date of death.

Consent and Institutional Review Board Approval

To ensure confidentiality, the interviews were conducted in a private and quiet place within the health facility and no personal information was disclosed to other parties except to the investigators. Administrative approval was obtained from the Ministry of Health and Sanitation for the investigation. Before the interviews started, a verbal informed consent was obtained from the case-patients or their families. However, ethical approval was not applicable to the investigation because it is part of a routine epidemic prone disease notification and case investigation.

Results

The Lassa fever outbreak investigation team identified two probable and three confirmed cases; two were from the community and three were medical staff working in the hospital one of which was an expatriate surgeon. Three died (case fatality ratio: 60%). Three cases were women. Two women from the community were pregnant. All of the five cases developed fever, three of them developed malaise, three developed vomiting, and two of them had bleeding.

Cases' Presentations

Case patient 1 (C1)

A 30-year-old pregnant woman, at gestational age of 38 weeks, probable case, started developing acute febrile illness symptoms on 30 Oct 2019. She was treated at a maternal and child health post on 3 Nov 2019 for fever, abdominal pain, vomiting, loss of appetite and vaginal bleeding. She was referred to a hospital in the Tonkolili District on the same day. The patient had surgery on 4 Nov 2019 for pregnancy-related complications and died on the same day due to heavy bleeding. The baby also died. No blood sample was taken from this patient as there was no suspicion of Lassa fever.

Case patient 2 (C2)

A 38-year-old male surgeon performed the caesarean section on C1 and did a manual evacuation on C5 later that day. The surgeon developed fever, headache, and malaise on 10 Nov 2019. He was treated for typhoid, malaria, and influenza, but his symptoms persisted. He was evacuated to the Netherlands on 19 Nov 2019 where he tested positive for Lassa fever. He died on 24 Nov 2019.

Case patient 3 (C3)

A 33-year-old female medical doctor, assisted in the operation of C1 and C5. She developed symptoms mainly fever, abdominal pain, vomiting and headache on 11 Nov 2019 and tested positive for Lassa fever on 21 Nov 2019. She was evacuated to the Netherlands on 23 Nov 2019. She was treated and recovered on 6 Dec 2019 in the Netherlands.

Case patient 4 (C4)

A 35-year-old male nurse, administered anaesthesia to case patients C1 and C5. He developed fever and malaise on 16 Nov 2019. A blood sample tested positive for Lassa fever on 22 Nov 2019. He was treated for Lassa fever and recovered on 23 Dec 2019.

Case patient 5 (C5)

A 33-year-old pregnant woman, at gestational age of 19 weeks, went to the hospital on 4 Nov 2019 and was operated on the same day. On 16 Nov 2019 she developed symptoms suggestive of Lass fever including fever, vomiting, and bleeding gums. She died on 19 Nov 2019 before Lassa fever was suspected. The same surgeons and anaesthetist operated on her on 4 Nov 2019 which was on the same day and in the same operating room as the first case (Figure 1).

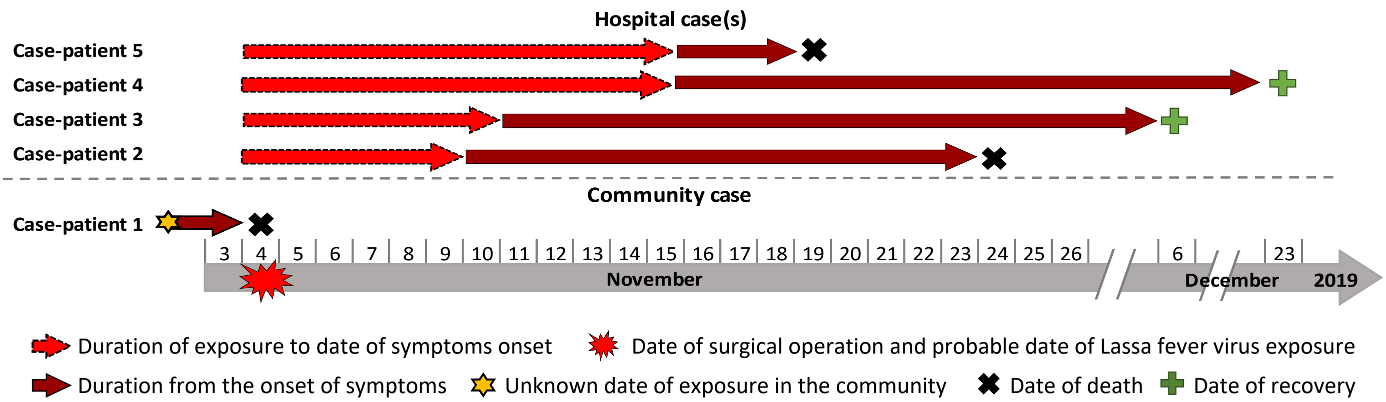

Figure 1. Transmission of Lassa fever infection in a Hospital, Tonkolili District, November 2019

C1 introduced Lassa fever to the hospital which resulted in transmission of Lassa fever virus to the medical staff, C2, C3, and C4, during her surgery. C5 entered the hospital and was operated in the same surgery room by the same medical staff as C1. C2, C3, and C4 had positive laboratory tests for Lassa fever. C1, C2, and C5 died, but C3, and C4 recovered. There was no evidence of epidemiological linkage between C1 and C5 in the community which strongly implies C5 was probably exposed in the hospital during operation.

Active Case Search

No additional cases were found in the affected hospital, in nearby health facilities, and in the communities of the case patients C1 and C5.

Contact Tracing Findings

Totally 276 contacts were identified from the probable and confirmed cases, 72 of the contacts were identified in Sierra Leone, and approximately 200 were identified in other countries. Forty-one of the 72 contacts in Sierra Leone were health care worker contacts at the Tonkolili hospital and two at the health post where C1 was treated initially. There were 24 contacts in the case-patients' community. Of the 204 contacts identified outside of Sierra Leone, 171 were in the Netherlands, 20 in the United Kingdom, 5 in Germany, 5 in Denmark, 3 in USA and from other countries. The international contacts were those who interacted with C2 and C3 during evacuation or during treatment in the Netherlands. The average number of contacts per case in this investigation was 56 (276/5). No contacts developed Lassa fever symptoms after 21 days since the onset date of the last case.

Environmental Assessment

Household waste was not properly stored and scattered all around C1's house, giving an opportunity for rodents to breed. Rodent droppings were also observed in C1's house, a mud house with a mud floor adjacent to a garbage dump. The house had an unprotected toilet facility used by many people. The general surrounding environment and food storage was untidy, and trash was scattered around the houses in the community.

Infection Prevention and Control Assessment

The investigation team found the availability of PPEs such as coveralls, face shields, gloves, and aprons. There were also running water, soap, handwash stations, and chlorine. The medical staff who were involved in the caesarian operation of two probable cases self-reported to have used gloves and face masks and followed hand washing protocols before and after operation. However, the assessment at the hospital revealed non-adherence to IPC procedures and some equipment such as autoclaves needed to maintain sterility were not available. The medical staff who participated in the operation of the pregnant women and who were interviewed during the assessment also reiterated that proper decontamination and sterilization of the surgical equipment was not done between the surgery of the two pregnant women. In addition to this, the investigation team also observed blood contaminated gloves scattered, blood spillover on the floor and other blood contaminated surgical equipment in the operating room which implies possible cross-contamination.

Discussion

A Lassa fever outbreak occurred in a hospital in the Tonkolili District, Sierra Leone in November 2019. Five people had Lassa fever, all had symptoms compatible with Lassa fever and three were laboratory confirmed. Lassa fever was reported after an expatriate surgeon, who was working at a hospital in the Tonkolili District, was evacuated to his home country. He had a positive test for Lassa fever. Based on the investigation findings, a pregnant woman, who was operated on by the surgeon, was the most likely source of this outbreak. Healthcare-associated transmission likely occurred due to poor IPC practices, including inadequate cleaning of the operating room between patients resulting in four additional cases. Presence of rodent droppings and garbage near the index case's house and no travel 21 days prior to onset of illness suggests that she may have been infected with Lassa fever virus at her residence.

The two pregnant women were not suspected and not tested for Lassa fever infection before they died. The surgeon was suspected and tested for Lassa fever only after he was evacuated to the Netherlands. This indicates that staff had low suspicion for Lassa fever. Detection, diagnosis, and management of Lassa fever remain major challenges among health care workers in developing countries, including Sierra Leone.

Lassa fever among pregnant women is usually fatal. A study conducted in Sierra Leone reported that 50% died due to Lassa fever.[7] In this study, C1 and C5 were both pregnant women who died from Lassa fever. Poor outcomes among pregnant women infected with Lassa fever virus are mainly due to the immunological changes during pregnancy, or the affinity of the virus to the highly vascularized placenta.[7] Delayed medical treatment may worsen the patient's prognosis. In addition, overlapping clinical symptoms such as abdominal pain, headache, and vaginal bleeding among pregnant women can cloud the diagnosis of Lassa fever.[8,9]

Lassa fever transmission occurs in healthcare settings where healthcare workers provide clinical care for patients.[10,11] In this outbreak, the healthcare workers might have been infected from C1's blood and other body fluids or a contaminated environment. C1 most likely contracted the Lassa fever virus at her home. However, in this study, no rodent trapping or investigation was conducted on rats in the primary case's house to identify the source of this outbreak.

Effective IPC measures are essential in healthcare settings to reduce the risk of disease transmission, including Lassa fever. Most healthcare-associated infections, including viral hemorrhagic fever, are attributed to poor IPC measures.[12] This healthcare-associated infection transmission implies poor adherence of healthcare workers to standard and transmission-based precautions. This poor compliance might have exposed the healthcare workers to this Lassa fever infection which finally led to death of two more people in this investigation. However, contact time for each of the cases was not collected during the investigation which limits this study from determining the infectious period of the cases.

Conclusion

A Lassa fever outbreak occurred in the Tonkolili District, Sierra Leone in November 2019. Five people has Lassa fever, and three were laboratory confirmed. Case-patient 1 was probably infected with Lassa fever before coming to the hospital. A low index of suspicion for Lassa fever and poor IPC practices contributed to the spread of Lassa fever to the operating medical team and to another patient in the hospital.

Public Health Action and Recommendations

The investigation team sensitized community members on Lassa fever prevention and control measures, including ways to decrease rodent populations in and around their homes. It is essential to strengthen community mobilization and report any suspected cases of Lassa fever to health facilities. Additionally, personal hygiene and environmental conditions for the community need to be improved to reduce reservoirs.

On-the-job training was conducted on Lassa fever case definition for health workers in the Tonkolili District to improve early case detection. In addition, the team provided guidance for case identification, particularly for the integrated disease surveillance and response focal points in different hospitals. Health authorities should ensure that health care workers in hospitals and healthcare facilities where Lassa fever was previously reported and also in surrounding areas must understand the transmission routes, clinical manifestations, management and protective measures for Lassa fever.

Health care workers were sensitized about IPC compliance and decontaminated of the operating room and wards. All febrile patients admitted for healthcare services should be assumed to be infected with bloodborne infectious agents and standard and transmission-based IPC precautions should be adhered to. Adherence to IPC practices is required in all healthcare facilities. Areas such as operating rooms are considered especially high-risk. IPC measures including training of healthcare workers on IPC practices and procedures, as well as ensuring an adequate supply of IPC supplies, such as PPE, are essential for preventing and controlling healthcare-associated infections. Periodic IPC assessments should be conducted in healthcare facilities to prevent healthcare-associated infections, including Lassa fever.

Disclaimer

The findings and conclusions in this report are those of the author(s) and do not necessarily represent the official position of the U.S. Centers for Disease Control and Prevention.

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Conflict of Interest

The authors declare no conflict of interest. No copyrighted materials were used in developing this article.

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Widespread Hand, Foot, and Mouth Disease Outbreaks: Interventions and Control Measures, Surin Province, 2020

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Abstract

In 2020, Surin Province had the highest incidence proportion of hand, foot, and mouth disease (HFMD) in Thailand, primarily concentrated in Mueang District. Numerous outbreaks occurred in kindergarten schools and child development centers despite the implementation of prevention and control measures. This study aimed to evaluate these interventions using observation and interviews and assess associated factors for the prolonged outbreaks. A cross-sectional study was conducted among 37 facilities that reported HFMD outbreaks. Linear regression analysis was performed to assess the association between factors and the duration of the outbreak. There were 369 confirmed HFMD cases. The attack rate in child development centers was 11.6%; in kindergarten schools was 5.1%. Most facilities with outbreak followed the recommendations and control measures issued by the Department of Disease Control; however, improper sanitation was observed in some facilities. A high student-toilet ratio (coefficient 0.64 days, [95% CI 0.11–1.17]) and a high student-janitor ratio (coefficient 0.12 days, [95% CI 0.07-0.17]) were associated with a longer outbreak duration. Prevention and control measures should include promoting personal hygiene, using an appropriate concentration of disinfectant solution, training teachers about common communicable diseases, early screening for detection and isolation of sick children, and communication with parents about HFMD.

Keywords: HFMD, kindergarten school, child development center, Thailand

Introduction

Hand, foot, and mouth disease (HFMD) is a common communicable disease among children. It is caused by a group of human enteroviruses from the family *Picornaviridae*. Enteroviruses are non-enveloped viruses with a single-stranded RNA genome. The common pathogens are Coxsackievirus A16 (CV-A16), Coxsackievirus A6 (CV-A6), and Enterovirus 71 (EV-A71). The most common clinical manifestation is a nonspecific febrile illness. Other manifestations include coryza, pharyngitis, herpangina, hand, foot, and mouth ulcer, and aseptic meningitis. Although HFMD is usually mild, it can also lead to severe conditions such as viral sepsis, meningoencephalitis, myocarditis, hepatitis, coagulopathy, and pneumonitis.[1,2]

HFMD spreads through direct contact with nasal and throat discharges via aerosol droplets and the feces of infected people. The incubation period ranges from 3–6 days and the median is about 4.4 days for children in kindergartens.[3] Enteroviruses can survive on environmental surfaces for periods long enough to allow transmission from fomites.[1] The antiviral action of chloroxylenol, benzalkonium chloride, and cetrimide/chlorhexidine is ineffective in inactivating enteroviruses.[4] Alcohol-based hand disinfectants with 70% ethanol or isopropanol also have poor effectiveness against EV-A71. Ninety-five percent ethanol is the most effective concentration, but this level still cannot fully inactivate EV-A71 and may be impractical in many instances.[5] Appropriate disinfectants include sodium hypochlorite, chlorine, glutaraldehyde, and formaldehyde, boiling at 50–60 °C for 30 minutes, sterilization, and ultraviolet light.[6]

The Department of Disease Control (DDC) of Thailand has provided recommendations for prevention and control measures toward common communicable diseases to kindergarten schools and child development centers. These recommendations include promoting proper personal hygiene, cleaning and disinfection, screening, isolation and administrative control, and health promotion.[7] A previous systematic review in China found that timely notification of HFMD outbreaks to national health authorities, effective communication, environmental disinfection and sanitation instructed by the facility, and control supervision from the local health authorities, are essential for minimizing the outbreak duration in childcare facilities.[8]

HFMD in Thailand is an epidemic. Historical data shows that there is a sharp peak during the rainy season (June–August).[9] However, as shown in Figure 1, the peak in 2020 occurred in November. This changed pattern might be caused by school closures during the COVID-19 pandemic.[10,11]

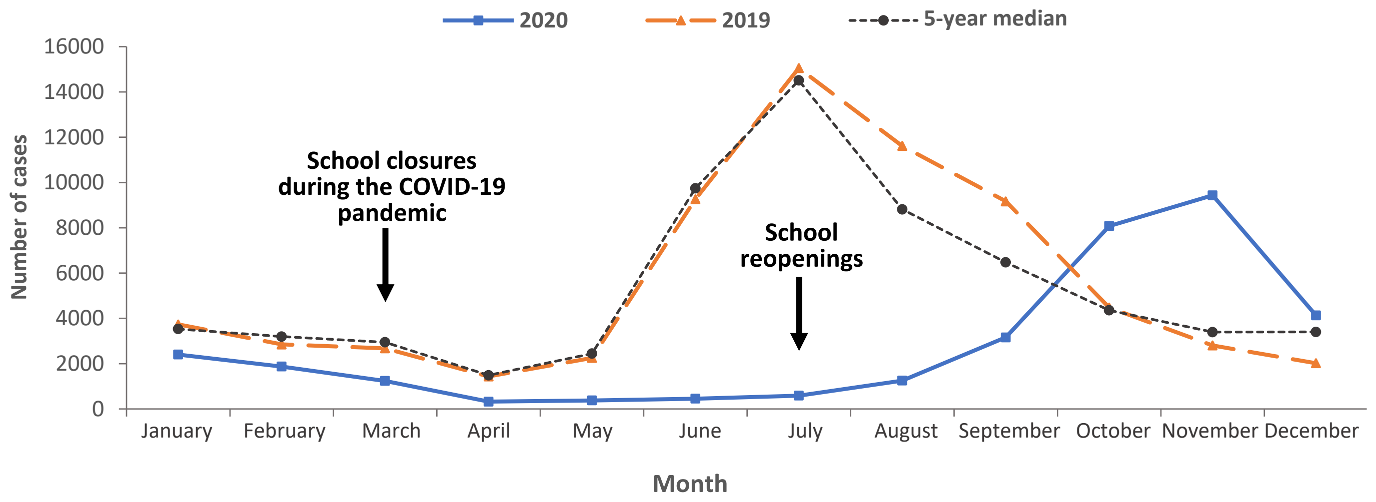

Figure 1. Illustration of the number of HFMD cases reported in National Disease Surveillance System, Thailand, in 2019, 2020 and the 5-year median (2015–2019)

On 2 Nov 2020, the Office of Disease Prevention and Control Region 9 Nakhon Ratchasima received a notification stating that the cumulative number of suspected HFMD cases in Surin Province was 1,223 (87.5 cases per 100,000 population). Despite conducting an investigation and receiving recommendations from the surveillance and rapid response team, the number of cases in Surin Province continued to rise and remained high. Consequently, a joint field investigation involving the Division of Epidemiology and Surin Provincial Health Office, investigated from 2–3 Nov 2020 and 16–18 Nov 2020.

The objectives of this study were to describe the epidemiological characteristics of HFMD outbreaks, evaluate the interventions implemented by kindergarten schools and child development centers, identify possible risk factors, and provide health education to prevent further outbreaks. We also aim to provide recommendations to health authorities for effective control measures of HFMD.

Methods

Study Area and Sampling Method

The study was conducted in Mueang District, Surin Province, which, in 2020, comprised 121 kindergarten schools and 68 child development centers. The child development center is a facility that provides daytime childcare and early childhood education for children aged 3–5 years, while the older children attend kindergarten schools. A facility with an outbreak was defined as a kindergarten school or child development center in the study area and had two or more HFMD cases in the same class or five or more cases in the facility between 1 Aug and 18 Nov 2020. Conversely, a facility without an outbreak was defined as one that did not meet any of the above criteria.[8,12] Purposive sampling was used to recruit facilities. We investigated every facility with an outbreak except ones that were closed during the 3-day field investigation period. Each of the four evaluation teams also investigated one facility without an outbreak per day. Provincial health officers who were responsible in the study area were actively participating in the investigation. We recruited 49 facilities, 37 with an outbreak, and 12 without. Figure 2 shows a flowchart of recruitment.

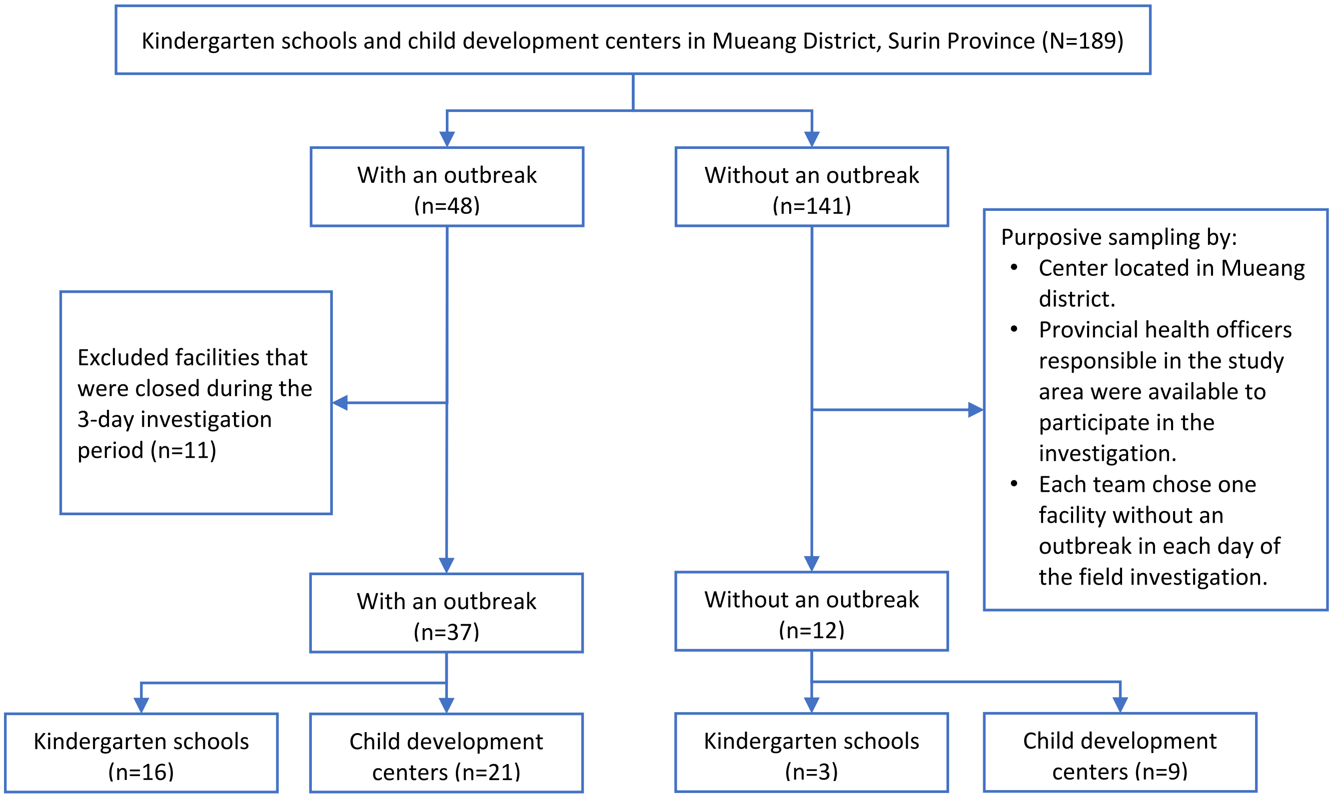

Figure 2. Recruitment flowchart for the study

Descriptive Study

A descriptive study was performed at both the individual and facility levels. We reviewed the classroom logbooks for absentees, and, for HFMD cases, we ascertained the date of symptoms onset (if any) among sick children. For facility-level data, we interviewed class teachers and school directors about their staff, HFMD cases, facilities, control measures, and school policies. We interviewed school teachers and cleaners about the use of the classrooms, toys, library, computer room, music room and toilets, and the cleaning methods and schedules during November 2022. We observed and interviewed teachers about student hygiene, daily screening methods, and teacher-parent management, and observed physical structures, toilets, and sanitation systems.

An active case finding was conducted among kindergarten students and children in child development centers. The suspected case was a student or child who met at least one of the following criteria from 1 Aug–18 Nov 2020: 1) maculopapular rash or vesicular rash on the palm, sole, oral cavity, trunk, or buttocks; and 2) diagnosed with HFMD by a clinician. A confirmed case was a suspected case who tested positive by reverse transcription-polymerase chain reaction (RT-PCR) for one of the Enterovirus genera from a throat swab, rectal swab, stool, or cerebrospinal fluid (CSF).[12]

Data Collection

We used a semi-structured questionnaire for data collection. The items in the questionnaire were arranged into characteristics, risk factors, and center interventions for HFMD. We arranged risk factors and interventions into four sections: personal hygiene; cleaning; screening, isolation, and administrative control; and communication. The sections were arranged according to the DDC recommendations and the communication part was an additional section. Proper cleaning was defined as 75–100% of items in facilities being cleaned properly. The cleaning recommendations were adopted from the DDC guideline. For items without DDC recommendations, sodium hypochlorite solution cleaning was considered proper.

Data Analysis

Continuous data were summarized as median with interquartile range (IQR) and categorical data were presented as frequency with percentage. An analytic study was performed to explore potential risk factors, especially behaviors and environments, among 37 facilities with an outbreak using a cross-sectional study design. Exposures were characteristics of the facility including the number of students or children, class size, number of teachers, cleaners and janitors, personal hygiene, and sanitation behaviors of the children such as use of toilets, sink, and drinking glasses. The dependent variable was the duration of the outbreak, defined as the days between the onset of the first case and the onset of the last case in each facility. Linear regression was performed to assess the association of potential risk factors and the outcome. All factors were presented as a coefficient with 95% confidence interval (CI). All *p*-values were two-tailed and the significance level was <0.05. All analyses were performed using STATA version 14.

Results

Of 189 kindergarten schools and child development centers in Mueang District, we recruited 49 facilities (19 kindergarten schools and 30 child development centers), 37 with and 12 without an outbreak. The first case was reported on 24 Aug 2020. The number of cases gradually increased and peaked in the first week of October. On 9 November, the last facility reported its first case.

Characteristic of Cases

Of 1,580 children from the 30 child development centers and 3,655 students from the 19 kindergarten schools, there were 369 suspected cases. The attack rate in child development centers was 11.6% (184 cases) and the attack rate in kindergarten schools was 5.1% (185 cases). From 37 facilities that we recorded symptoms from 191 children, most cases had an oral ulcer (69.1%), followed by a rash on the palms (51.3%), and fever (31.4%). Other less common symptoms included sore throat, fatigue, nausea (18.8% each), and rash on the soles (13.1%).

Characteristics of HFMD Outbreaks in Facilities

The median number of cases reported from facilities with an outbreak and those without an outbreak was six and one, respectively. Most facilities with an outbreak had cases in two classrooms and those without an outbreak in one classroom. Attack rates among facilities with and without an outbreak were 9.8% and 3.1%, respectively. As shown in Table 1, the median (IQR) duration of outbreaks in centers with an outbreak was 11.0 (3.0–24.0) days while the duration in centers without an outbreak was 0 (0–3.3) days.

Table 1. Characteristics of hand, foot, and mouth disease outbreaks in facilities with and without an outbreak, Surin Province, 2020

Characteristic	Facilities with an outbreak			Facilities without an outbreak		
	Kindergarten schools (n=16)	Child development centers (n=21)	Total (n=37)	Kindergarten schools (n=3)	Child development centers (n=9)	Total (n=12)
No. of cases						
median	5.0	6.0	6.0	1.0	1.0	1.0
(IQR)	(3.0–14.5)	(4.0–10.0)	(4.0–11.0)	(0.0–3.0)	(1.0–1.5)	(1.0–1.8)
No. of classes with a case						
median	3.0	2.0	2.0	1.0	1.0	1.0
(IQR)	(1.3–4.0)	(1.3–2.0)	(1.3–3.0)	(0.0–3.0)	(1.0–1.5)	(1.0–1.8)
Attack rate (%)						
median	6.8	9.9	9.8	4.2	2.9	3.1
(IQR)	(3.5–17.6)	(7.4–19.1)	(6.1–18.2)	(0.0–6.7)	(2.2–4.8)	(2.2–4.9)
Duration of outbreak						
median	17.0	9.0	11.0	0.0	0.0	0.0
(IQR)	(1.5–34.5)	(4.0–18.0)	(3.0–24.0)	(0.0–41.0)	(0.0–1.0)	(0.0–3.3)

IQR: Interquartile range

Characteristics of Facilities

Characteristics of studied facilities are presented in Table 2. The median number of classrooms was three among facilities with an outbreak and two among those without. Most facilities had less than 15 students per teacher, which was within the standard requirements.[13] However, the median student per teacher ratio was 21 in kindergarten schools without an outbreak. All study facilities had an adequate student per sink ratio. However, most facilities had an inadequate student per toilet ratio; the median ratio in facilities with and without an outbreak was 11.0 and 15.5, respectively. The median (IQR) number of students per janitor and students per playground was 37.5 (16.0–72.3) and 41.0 (32.3–74.3) in facilities with an outbreak, and 35.5 (25.5–41.8) and 27.0 (17.4–44.3) in facilities without an outbreak, respectively.

Table 2. Characteristic of facilities with and without an outbreak, Surin Province, 2020

Characteristic	Facilities with an outbreak			Facilities without an outbreak			Requirement[16]
	Kindergarten schools (n=16)	Child development centers (n=21)	Total (n=37)	Kindergarten schools (n=3)	Child development centers (n=9)	Total (n=12)	
No. classrooms							
median	4.0	2.0	3.0	2.0	2.0	2.0	-
(IQR)	(2.0–15.8)	(2.0–3.0)	(2.0–5.0)	(2.0–2.0)	(1.0–2.5)	(1.0–2.0)	
Student/teacher							
median	13.6	12.8	12.9	21.0	11.3	12.2	15/1
(IQR)	(10.2–14.9)	(10.8–15.6)	(10.7–15.0)	(12.0–22.5)	(10.1–16.9)	(10.3–20.4)	
Student/janitor							
median	31.1	38.0	37.5	42.0	34.0	35.5	-
(IQR)	(17.0–106.8)	(8.0–65.0)	(16.0–72.3)	(24.0–45.0)	(15.0–39.0)	(25.5–41.8)	
Student/playground							
median	59.0	41.0	41.0	42.0	23.0	27.0	-
(IQR)	(16.3–133.0)	(33.0–60.5)	(32.3–74.3)	(24.0–45.0)	(8.5–41.5)	(17.4–44.3)	
Student/sink							
median	5.8	8.8	6.8	5.6	6.3	6.0	10/1
(IQR)	(4.2–14.0)	(4.7–15.0)	(4.5–14.1)	(2.2–14.0)	(2.6–8.9)	(2.5–9.1)	
Student/toilet							
median	13.0	10.0	11.0	14.0	16.0	15.5	10–12/1
(IQR)	(6.4–25.3)	(7.8–17.3)	(7.8–20.3)	(12.0–22.5)	(10.9–19.8)	(11.6–20.4)	

IQR: Interquartile range

Personal Hygiene

We found that 70% of facilities with an outbreak and 50% of those without an outbreak had student face towels in contact with each other. From our observations, the space for hanging towels appeared inadequate. Sharing of hand towels was observed in 43% and 25% of facilities with and without an outbreak, respectively, while sharing of hand-washing basins was seen in 14% and 8%, respectively. The sharing of drinking glasses and/or glasses that were in contact with each other stored on glass racks was seen in 16% and 17% of facilities with and without an outbreak, respectively (Figure 3).

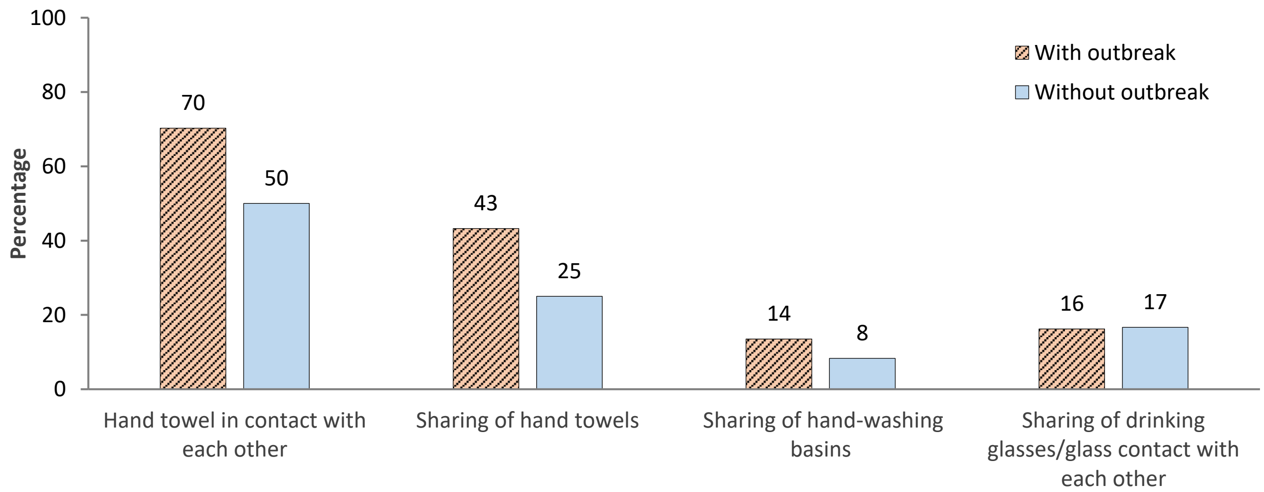

Figure 3. Personal hygiene levels in facilities with and without an outbreak, Surin Province, 2020

HFMD Prevention Measures

Cleaning

Most facilities used chloroxylenol and diluted hypochlorite for cleaning purposes. From our observations, items were cleaned with improper methods and inadequate frequency. We found only three facilities (8%) with an outbreak properly cleaned all six items recommended in the guideline, plus the three we added in based on the school context. The top three items with proper cleaning methods in facilities with an outbreak were dolls, drinking glasses, and books while in centers without an outbreak were drinking glasses, hand towels, and books. Compared to facilities without an outbreak, facilities with an outbreak had more proportion of cleaning computers, musical instruments and playgrounds with sodium hypochlorite solution (Table 3).

Table 3. Implementation of proper cleaning interventions in facilities with and without an outbreak (%), Surin Province, 2020

Intervention	Recommendation [a]	Facilities with an outbreak (n=37)	Facilities without an outbreak (n=12)
Cleaning			
Drinking glasses	Use personal drinking glasses and clean with dishwashing liquid (once a day)	83.8	83.3
Hand towels	Use personal towels and clean with detergent and air dry (once a day)	56.8	75.0
Toys	Should clean with disinfectant and air dry (once a day for sucking toys and once a week for other toys)	29.7	25.0
Dolls	Should clean with disinfectant and air dry (once a week)	100.0	50.0
Books	Should dust (once a week)	60.9	55.6
Floors	Clean with detergent or disinfectant (once or twice a day)	24.3	16.7
Computers [b]	-	33.3 [c]	
Musical instruments [b]	-	25.0	0.0
Playgrounds [b]	-	21.4	10.0

[a] Department of Disease Control recommendations unless stated otherwise.
[b] Additional evaluation items.
[c] Among facilities that had computers for students to use.

Screening, isolation, and administrative control

Thirty-six facilities with an outbreak (97%) and 12 without (75%) implemented temperature screening to staff and students/children on entering the facilities. Twenty-eight facilities with an outbreak (76%) and 6 without an outbreak (50%) implemented HFMD screening for those entering classrooms. However, in only 13 facilities (11 with an outbreak and 2 without an outbreak) teachers/staff used a torch while screening for oral lesions. Half of all facilities implemented isolation measures for sick children (20 with an outbreak and 6 without). We found that 35 facilities with an outbreak and 8 without suspended classes during disease outbreak periods and 34 facilities with an outbreak and 10 without closed their facility. Only 22 centers with an outbreak (59.5%) and 5 without an outbreak (41.7%) trained teachers about common communicable diseases that can occur in schools every year (Table 4).

Communication

Parent-teacher communication about the HFMD situation or provided health information to parents was good with 89% of facilities with an outbreak and 75% without, implementing this control measure (Table 4).

Table 4. Implementation of screening, isolation, and administrative control and communication measures completely done in facilities with and without an outbreak (%), Surin Province, 2020

Intervention	Recommendation [a]	Facilities with an outbreak (n=37)	Facilities without an outbreak (n=12)
Screening, isolation and administrative control			
Temperature screening [b]	-	97.3	75.0
HFMD screening	Screen at least two weeks after the last case had occurred.	75.7	50.0
Use of a torch while screening for oral lesions [b]	-	29.7	16.7
Separation zone	Isolate sick children at a distance of at least one meter from others	54.0	50.0
Class suspension	Suspend if more than two cases in one week in the same class occurred.	94.6	66.7
Facility closure	Close if more than five cases in the school or more than two classes occurred.	91.9	83.3
Training of teachers/staff about communicable diseases	Train at least once a year	59.5	41.7
Communication			
Communicates with parents about HFMD situation or provides health information to parents [b]	-	89.2	75.0

[a] *Department of Disease Control recommendations unless stated otherwise.*
[b] *Additional evaluation items.*

Risk factors for duration of HFMD outbreaks

The univariable analysis results are summarized in Table 5. A high student per toilet ratio and a high student per cleaner and janitor ratio were significantly associated with a longer outbreak duration. For every unit increase in student per toilet ratio and student per cleaner and janitor ratio the outbreak duration would increase by 0.64 day or approximately 15 hours and 0.12 day or 3 hours, respectively.

Table 5. Coefficients of risk factors relating to duration of outbreak (n=37)

Variables	Coefficients relating to duration of outbreak	95% CI	*P*-value
Characteristics			
Student/teacher ratio	-0.49	-1.96–0.98	0.500
Student/toilet ratio	0.64	0.11–1.17	0.020
Student/sink ratio	-0.08	-0.56–0.39	0.722
Student/cleaner and janitor ratio	0.12	0.07–0.17	<0.001
Practices			
Towel contact with each other	8.89	-2.02–19.80	0.107
Sharing hand towels	-0.39	-10.85–10.06	0.940
Sharing basin for hand washing	-4.83	-19.88–10.23	0.520
Sharing drinking glasses	-5.54	-19.46–8.38	0.425

CI: confidence interval

Discussion

Most kindergarten schools and some child development centers lacked adequate toilet facilities. The minimum requirement is one toilet per 10–12 students.[14] In our analytic study, we found that in centers with an outbreak, a high student per toilet ratio was significantly associated with a longer outbreak duration. Without enough toilets, waste from infected individuals can contaminate school sanitation facilities. The absence of basic sanitation facilities can both result in an unhealthy environment contaminated by human waste and contribute to the spread of many diseases.[15]

The analytical study also showed that a high student per cleaner and janitor ratio was associated with a longer duration of the outbreak. Cleaning and disinfecting are part of a broad approach for the prevention of infectious diseases in schools.[16] Maintaining cleanliness is linked to the health of students, and janitors bear the responsibility for ensuring a hygienic environment.[13] They reduce the risk of illnesses being spread and can help keep the school a healthier and safer place.[17] One study even reported a relationship between inadequate janitorial service and student attendance.[18] In the US, the requirement for janitors is to clean 30,000 square feet within 8 hours.[19] However, in Thailand, there are no specific requirements regarding the workload for janitors. Differences in the size of school buildings and the extent of school grounds requires different duties assigned to janitor and determine the amount of work required for them.[20]

In most facilities we observed, the child's towels were in contact with each other, and in some facilities, students shared hand towels. An outbreak of methicillin-resistant Staphylococcus aureus among college football players found that sharing towels on the field facilitated the transmission of infectious diseases.[21] Another study found the presence of *Escherichia coli* bacteria and coliform on kitchen hand towels, and the number of bacteria negatively correlated with frequency of towel washing.[22]

Most facilities used improper disinfectants for cleaning or washing. Few facilities used proper interventions on cleaning. Diseases can spread easily in the community if control measures such as use of disinfectants are not applied properly. The appropriate concentration of sodium hypochlorite in disinfectants is 600 parts per million (ppm) for toys and 1,000 ppm for floors and surfaces.[6,21,23] However, there are no recommendations about proper disinfectants and concentrations for cleaning in the DDC guideline. In addition, the guideline does not include recommendations for cleaning some items such as computers, musical instruments, and playground equipment.

Many facilities did not follow the teacher training recommendations. Moreover, some did not screen for HFMD symptoms at least 2 weeks after the last case had occurred and few facilities used a torch when performing oral examinations. HFMD screening should be implemented for at least 2 weeks after the last case had occurred.[7] Torches should be used for oral mucosa examination.[24,25]

Half of the facilities did not isolate sick children and some did not implement class suspension or facility closure. These practices are risky because children with HFMD are usually most contagious during the first week of infection.[26] A study in China found that the median basic reproduction number for HFMD was 4.6 indicating that the virus can spread easily.[3] Home isolation is a key strategy for preventing the spread of disease and limiting person-to-person contact is one of the prevention measures of HFMD.[27,28]

We found that in 90% of facilities with an outbreak and 75% without an outbreak teachers communicated with parents about HFMD and provided relevant health information. A previous study showed that prevention behaviors of parents had a significantly positive relationship with health literacy, especially in access to information.[29] Factors affecting prevention behaviors of HFMD included perceptions of the severity, disease prevention, and barriers to the prevention of disease, and obtaining support from relevant persons.[30] Providing knowledge and disseminating health information related to HFMD regularly to parents can also enhance preventive health behaviors.[31]

Public Health Actions and Recommendations

We provided health education about the mode of transmission and clinical manifestations. We demonstrated how to perform HFMD screening and clarified the proper disinfectant and concentration of hypochlorite for cleaning.

Kindergarten schools/child development centers should provide sufficiently clean and functioning toilets to children and provide appropriate hand-washing facilities. Having an adequate number of cleaners and janitors are also important. The number depends on the duties and size of the facility. The facilities should provide adequate spaces for hanging towels and the sharing of hand towels should be discouraged. Classroom toys, floors, and common areas should be cleaned with proper hypochlorite solution and optimal frequency. An isolation room for sick children should be provided. facilities should consider DDC recommendations on class suspensions and facility closures. When the facility is reopened, staff should screen children before they enter the facility every day for at least two weeks. The facilities should also communicate and provide information about HFMD to parents. Moreover, having empowerment activities for parents to encourage them to have a better awareness of HFMD and to promote the health of children is essential.[30] For the DDC, instructions on the proper disinfectants for cleaning purposes should be provided in the guideline.

Limitations

As this study design was retrospective, virus isolation of causative strains to confirm HFMD cases was not conducted. In addition, limitations in resources, time, and human workforce prevented us from selecting a random sample of facilities; thus, some selection bias may have occurred.

A demonstration by the teachers, cleaners, and janitors in their cleaning and screening processes might have differed from their actual practices. Inaccurately measured or classified practices may have caused information bias. However, where possible, we used direct observation to reduce the bias.

Observations from the classroom logbooks indicated that the absentee students had unknown dates of symptom onset, which might have led to misclassification bias.

In many facilities, an outbreak occurred before we had conducted the investigation. In those facilities, interventions and control measures had already been implemented. Therefore, facilities with outbreaks had a higher proportion of proper interventions than those without an outbreak. Finally, cross-sectional studies cannot provide firm evidence of causation. Results from this study may be inadequate for establishing a clear temporal sequence. We were therefore unable to determine causality between some risk factors and the duration of HFMD outbreaks.

Conclusion

We reported HFMD outbreaks in kindergarten schools and child development centers in Mueang District, Surin Province. The attack rate in child development centers was higher than in kindergarten schools. Common symptoms included oral ulcers, rash on the palms, and fever. No case developed severe symptoms or conditions. Most facilities reporting an outbreak followed recommendations and control measures issued by the DDC. However, we found improper sanitation methods used in some facilities. Facilities with a high student per toilet ratio and student per cleaner and janitor ratio had a significantly longer outbreak duration. Prevention and control measures should include promoting personal hygiene, using an appropriate concentration of disinfectant solution, training teachers about common communicable diseases, early screening for detection and isolation of sick children, and increased communication with parents about HFMD.

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Investigation of a COVID-19 Cluster in a Football Academy of Buri Ram, October 2021

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Abstract

A COVID-19 cluster in a football academy, Buri Ram, Thailand, was notified in October 2021. We aimed to characterize the outbreak, identify the source of disease and risk factors for infection, and give recommendations for preventive measures. We conducted a descriptive study by interviewing cases and academy participants, and assessed ventilation measures at the academy via an environmental survey. We performed a retrospective cohort study among football players using Poisson regression to identify risk factors of COVID-19 infection presenting adjusted incidence rate ratios (AIRR) and 95% confidence intervals (CI). The attack rate was 22.4% (48/214). The median age was 14 years and 77.1% of patients had mild illnesses. All examined environmental surfaces tested negative for SARS-CoV-2. The bedroom density had a strong relationship with attack rates among female bedrooms. Risk factors for infection were being high-risk close contact with the primary case (AIRR 5.4, 95% CI 2.2–12.9) and sleeping in crowded bedrooms (AIRR 2.42, 95% CI 1.14–5.15). Mask-wearing was a protective factor (AIRR 0.32, 95% CI 0.13–0.80). We recommend sports academies and schools encourage mask-wearing during an outbreak, provide living areas that conform to recommended density guidelines, and prepare an isolation or quarantine room for infected students.

Keywords: COVID-19, football academy, risk factors, school

Background

Thailand began experiencing a sharp rise in coronavirus disease 2019 (COVID-19) cases in April 2021, with a peak number reported on 13 Aug 2021.[1] The Thai government used a variety of control strategies, including promoting global COVID-19 prevention measures, limiting group activities, closing high-risk areas and buildings, limiting mobility, and implementing control measures tailored to particular risk areas. Every school closed down and implemented online learning.[2] Consequently, the number of cases fell from September to October 2021.[1] COVID-19 immunization for adolescents (ages 12 to 18 years) began in October 2021, and classes resumed in early November 2021.[3,4] Thailand provided recommendations for re-opening schools and sports venues.[5–7] Before October 2021, there were three COVID-19 outbreaks in sports schools but no outbreak in sports facilities.[8] However, there has been no previous study exploring risk factors for COVID-19 outbreaks in schools or sports facilities in Thailand.

The proportion of asymptomatic COVID-19 infections among children and adolescents ranges from 15–42%.[9]

Among symptomatic cases, fever and cough were the most common symptoms. Other symptoms, including rhinorrhea, sore throat, diarrhea, and vomiting, are less common. Disease is rarely severe and the mortality rate is low.[10] Higher transmission rates are observed in older children (ages 10–19 years) compared with younger children (<10 years).[11] COVID-19 transmission rates in schools are low.[11,12] Lack of masking, staff-to-staff dining, and team sports or other types of group extracurricular activities are risk factors for in-school transmission.[13–15] Group living environment and poor ventilation are environmental risk factors for COVID-19.[16,17]

On 13 Oct 2021, Buri Ram Provincial Health Office notified the joint investigation team of the Office of Disease Prevention and Control Region 9 Nakhon Ratchasima about a COVID-19 cluster in a football academy at a secondary school in Nai Mueang Subdistrict of Mueang Buri Ram District, Buri Ram Province, Thailand. An investigation was conducted aiming to describe epidemiological characteristics of the outbreak, identify potential sources of disease transmission, identify risk factors of COVID-19 infection, and recommend preventive measures.

Methods

An investigation was conducted at school M, Muang District, Buri Ram Province, between 14 Oct and 7 Nov 2021, by a joint investigation team that included officers from the Office of Disease Prevention and Control Region 9 Nakhon Ratchasima, Buriram Hospital, Buri Ram Provincial Health Office, and the Division of Epidemiology.

A descriptive study was performed by reviewing Novelcorona-3 form (Thailand's COVID-19 patient summary report form), field hospital records and laboratory data, and interviewing football players, coaches, and directors. Contact tracing, active case finding, and laboratory testing was also performed.

A confirmed case of COVID-19 was defined as a person who lived in school M and had a positive result for severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) by real-time reverse transcription–polymerase chain reaction (RT-PCR) method at Buriram Hospital between 23 Sep and 7 Nov 2021.

A close contact was defined as a person who came into contact with a confirmed case or talked to a confirmed case within a distance of one meter for at least five minutes, or was exposed to the secretion of a confirmed case, or stayed in a closed environment with a confirmed case for at least 30 minutes, and came into contact with the case between two days before the case's onset date and the date of their isolation. The date of contact or exposure must have occurred between 23 Sep and 7 Nov 2021. If a confirmed case was asymptomatic, we used the detected date as the onset date. A high-risk close contact was defined as a close contact who did not wear proper personal protective equipment or was a roommate of a confirmed case, otherwise, the person was defined as a low-risk close contact.

Nasopharyngeal swabs were collected from all students in the football academy, basketball academy and personnel in school M for active case finding. The specimens were sent to the certified laboratory of Buriram Hospital. We recorded the cycle threshold level of the RNA-dependent RNA polymerase (RdRp) gene, nucleocapsid (N) gene, and envelope (E) gene.

The environmental study was conducted in the football academy via a walk-through survey to determine possible transmission locations. We interviewed cases, football coaches, and football players to describe risky behaviors, risky activities, and any COVID-19 preventive measures that were implemented. We swabbed environmental surfaces at common contact points, toilets, and dormitories, and submitted the specimens to Nakhon Ratchasima Medical Sciences Center for RT-PCR testing. We measured the dimensions of the academy to estimate the crowd density using a laser distance meter. We measured the airflow rate in air changes per hour (ACH) using a hot-wire anemometer, the air direction using a smoke tube, and the ventilation size of football players' bedrooms.[18] We fit a linear regression model to the attack rate in bedrooms to identify associated environmental factors.

A retrospective cohort study was conducted to identify risk factors of being a COVID-19 case in the football academy. The study population consisted of all football players who lived in school M between 23 Sep and 7 Nov 2021 and had no evidence of COVID-19 infection (RT-PCR or antigen test kit results) before the study period and responded to a survey via Google Forms. We elicited participant's age, gender, underlying disease, vaccine history, and behaviors through a structured questionnaire. Answers to the behavior questions were "always", "sometimes", and "never". We classified those who responded "always" or "sometimes" as the exposure group and "never" as the non-exposure group. We defined the cohort beginning on 7 October since this was the onset date of the primary case, and we followed up participants until 4 Nov 2021 (14 days after the last case was detected).

For the descriptive analysis, we present median and interquartile range for continuous variables and frequency and percentage for categorical variables. Microsoft Excel 365 was used for data management. We performed univariate analysis using Poisson regression and multivariate analysis using a backward stepwise method by including variables with a *p*-value <0.2 from the univariate analysis. A variable with a *p*-value <0.05 was considered statistically significant. We calculated person-time from the cohort beginning from being a COVID-19 case until the end of the study period. For those who had no person-time defined, we used a value of 0.5 person-days. STATA version 16.0 was used for all statistical analyses.

Ethics

Participants gave their verbal consent to join the study. The participants' names were not recorded to ensure anonymity. This study was conducted as part of an emergency public health response. There were no invasive procedures in this investigation.

Results

School M is a public school catering for primary and secondary students. Football and basketball are the two-sport academies in this school. During the outbreak, all classes were closed. At the time of our investigation, the school housed 214 people including 59 female and 120 male football players, 18 female basketball players, and 17 staff (15 football staff, 2 basketball staff). Teachers at the school had no contact with the sports academy. Both sports academies were separated from each other and neither students nor staff communicated with those from the other academy. On 13 Oct 2021, 16 confirmed COVID-19 cases were detected (15 female football player and one male football player) from 194 persons who were in the football academy. The joint investigation team started investigating the outbreak on 14 Oct 2021. The remaining 163 football players and 15 football staff were defined as high-risk close contacts. RT-PCR tests for SARS-CoV-2 were performed on days 0, 7, 14, and 21 after the investigation. We conducted active case findings on the female basketball players, staff, administrative officers, and teachers. The outbreak was monitored for 14 days after the last case was reported.

The distribution of COVID-19 cases by date of onset in the football academy is shown in Figure 1. During 23–30 Sep 2021, all players went back to their homes. On 1 October they returned to the academy where they were screened for SARS-CoV-2 using antigen test kits, of which all results were negative. On 5 October, all players received their first dose of the COVID-19 vaccine (BNT162b2) at Buriram Hospital. The primary case was a 15-year-old female who developed symptoms on 7 October. She went to a coffee shop with her family on 30 September before returning to the academy on 30 September and developed a fever on 7 October. Her entire family was not infected with COVID-19. Because the staff assumed that her symptoms were side effects from the vaccination, they did not consider that she had COVID-19 and did not isolate her. Five female football players developed symptoms a few days later. On 12 October, staff transported ten female football players to Buriram Hospital, of which eight tested positive for SARS-CoV-2. The field investigation began on 14 October. The football academy implemented group quarantine for all high-risk contacts on 15 October and the number of cases reported each day began to decrease. The last case was reported on 24 Oct 2021.

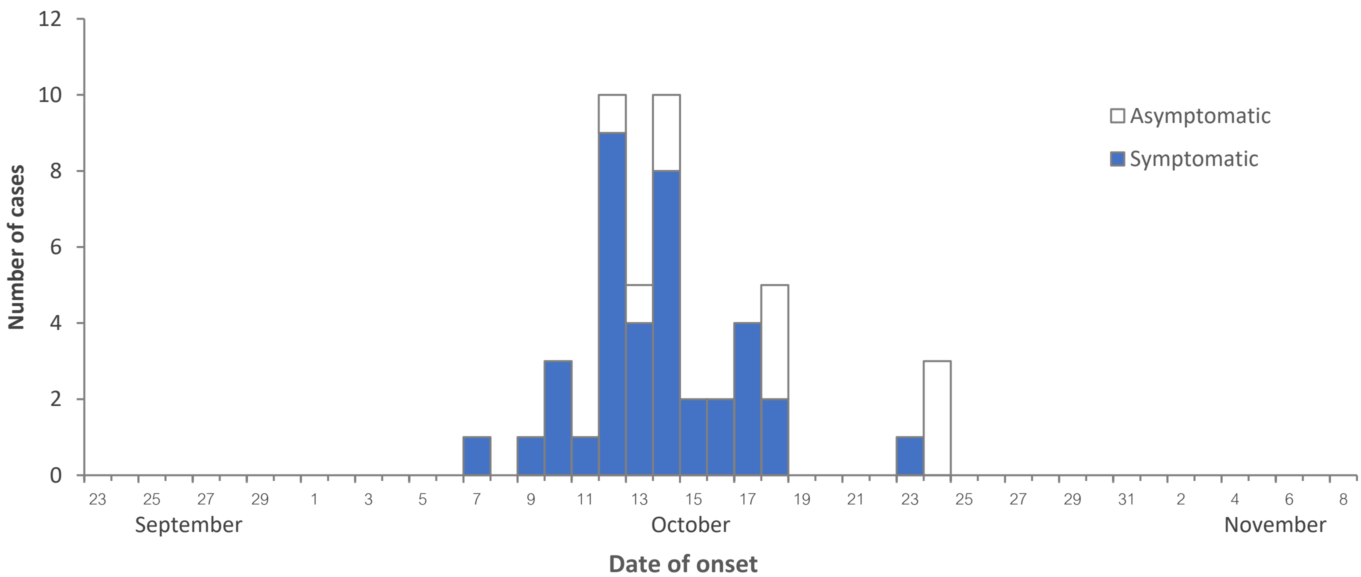

Figure 1. Distribution of COVID-19 cases by onset/detected date in a football academy from 23 Sep–7 Nov 2021 (n=48)

Epidemiological Characteristics of the Outbreak

From September to November 2021, there were 48 confirmed COVID-19 cases in school M giving an overall attack rate of 22.4% (48/214). Table 1 presents demographic and clinical characteristics of the cases. The median age was 14 years (interquartile range (IQR) 12–17 years) and the female to male ratio was 1.29:1. One case had an underlying disease (glucose-6-phosphate dehydrogenase deficiency). The cases consisted of 27 female and 21 male football players. No case was detected among coaches, staff, basketball players, teachers, nor administrative officers. The gender-specific attack rate was 45.8% in female football players (27/59) and 17.5% in male football players (21/120).

Table 1. Demographic and clinical characteristics of COVID-19 cases (n=48)

Characteristics	n (%)
Age group (years)	
12–14	25 (52.1%)
15–17	23 (47.9%)
Median age (IQR)	**14 (12–17)**
Gender	
Female	27 (56.2%)
Male	21 (43.8%)
Female to male ratio	**1.29:1**
Underlying disease	
Yes	1 (2.1%)
No	47 (97.9%)

IQR: interquartile range

Most (77.1%) cases were symptomatic with the main symptoms being cough (62.2%), sore throat (56.8%), fever (40.5%), rhinorrhea (35.9%), and headache (33.3%). Other symptoms included secretions, anosmia, ageusia and myalgia. All cases were taken to a field hospital. There were no severe cases and no deaths reported. The median cycle threshold level for the RdRp gene was 21.59 (IQR 14.70–27.67) and for the N and E genes was 23.48 (IQR 16.39–29.07), and 22.64 (IQR 15.58–28.01), respectively.[21] On 5 Oct 2021, all 48 cases received a single dose of the BNT162b2 vaccine, with 16, 26, and four developing symptoms or vaccine side effects between 0–7 days, 8–14 days, and 15–21 days after vaccination, respectively.

Environmental Study

All football players and staff were living in the football academy at school M. Every morning, staff would screen the players for signs of fever and respiratory symptoms. If someone showed symptoms, staff would transport them to a hospital for further investigations.

Daily activities at the academy included two hours of group exercise per day, two hours of football practicing per day, and six hours of online studying per day. Players did not wear masks during group exercises or football practice. Inactive players gathered in groups on the sidelines.

At the academy, common areas have multipurpose tables, water dispensers, and toilets. The multipurpose tables are used for dining, studying, and relaxing (such as group conversations and playing cellphone games). During meal times the players are closely seated at the dining table. Separate times are allocated for males and females and the table is cleaned after use with alcohol spray. The press botton of the water dispenser and the drinking glasses are shared. There are separate toilets for males and females but there are no private bathrooms. Almost all bathrooms have a water retainer, bowl, faucet, and water closet. The bathrooms are cleaned twice a week.

There are 12 shared bedrooms, of which five are designated for females (8–15 per room) and seven for males (12–24 per room). All bedrooms contain air conditioners and the spacing between the beds ranges from 0–0.5 meters. The air-conditioning is usually on while the players are in their bedrooms. A mop with floor cleanser is used to clean the bedroom floors daily. There are no isolation or quarantine rooms at the academy.

On the investigation day, we collected 28 samples from surface areas for RT-PCR testing for SARS-CoV-2. All samples were collected before cleaning the areas. We selected three bedrooms (two females, one male) based on the ones with the highest attack rates on the investigation day. We collected five samples from each of the bedrooms; one each from a light switch, floor, bedrail, doorknob, and air-conditioning outlet. We collected nine samples from three of the toilets (two females, one male); three each from the toilet bowls, faucet handles, and seat cover surfaces. We collected four samples from two side table surfaces and the press buttons from two water dispensers. All specimens tested negative for SARS-CoV-2.

Table 2 provides detailed characteristics of each of the 12 bedrooms at the academy. The median (IQR) density was 1.5 (1.3–1.6), air changes per hour (ACH) was 7.33 (2.05–21.19), and the attack rate was 19.5% (6.6–39.4).

Table 2. Characteristics of bedrooms in the football academy

Room	Area (m^2)	Volume (m^3)	Airflow rate (m^3/hr)	Ventilation rate (m^3/hr/person)	ACH (L/hr)	Crowd density (person/4 m^2)	Specific attack Rate (%)
1F	48.0	132.1	2,592	216.00	19.62	1.00	16.67 (2/12)
2F	38.6	109.5	3,924	301.85	35.83	1.35	53.85 (7/13)
3F	40.2	108.4	252	16.80	2.32	1.49	86.67 (13/15)
4F	28.1	75.6	2,556	232.36	33.79	1.56	45.45 (5/11)
5F	28.1	75.6	1,692	211.50	22.39	1.14	0.00 (0/8)
1M	48.0	102.6	756	63.00	7.37	1.42	33.33 (4/12)
2M	37.1	112.9	144	12.00	1.28	2.37	18.18 (4/22)
3M	37.1	102.6	2,052	136.80	19.99	1.63	13.33 (2/15)
4M	44.8	137.6	396	19.80	2.88	1.79	30.00 (6/20)
5M	36.7	123.9	180	12.86	1.45	1.53	0.00 (0/14)
6M	39.2	118.4	864	66.46	7.30	1.33	0.00 (0/13)
7M	60.0	160.7	288	12.00	1.79	1.60	20.83 (5/24)
Median	38.9	111.2	810	64.73	7.33	1.51	19.50
(IQR)	(36.9–46.4)	(102.6–128)	(270–2340)	(14.83–213.8)	(2.05–21.19)	(1.34–1.62)	(6.66–39.39)

M: male, F: female, ACH: air changes per hour

There was no association between any of the bedroom characteristics and bedroom-specific attack rates. However, among female bedrooms, the density had a positive linear relationship (r=0.77) with the specific attack rate. From the linear regression the relationship was not statistically significant (regression coefficient 109.96, *p*-value 0.130) (Figure 2).

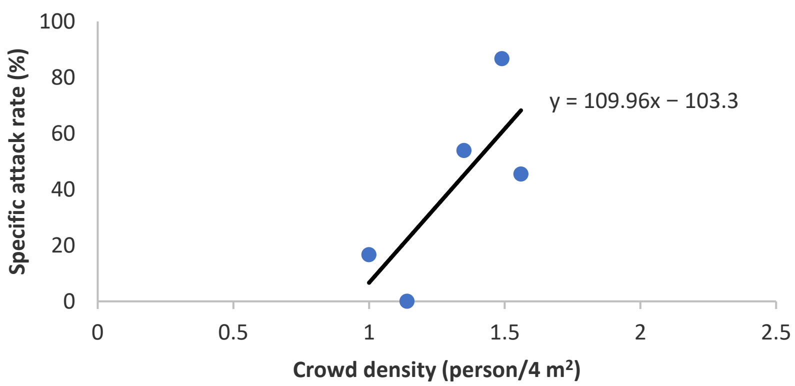

Figure 2. Scatter plot showing the relationship between crowd density and specific attack rate among female bedrooms. The black line represents fitted values from a linear regression model (n=5)

Risk Factors of Being a COVID-19 Case in the Football Academy

Of all 179 football players at the academy, 176 responded to the online survey and none reported ever being infected with COVID-19. Overall, 48 (27.3%) players were infected with COVID-19. Univariate analysis showed that factors associated with being a COVID-19 case were female gender (incidence rate ratios (IRR) 3.57, 95% CI 2.01–6.31), being a high-risk close contact of the primary case (IRR 7.85, 95% CI 4.42–13.93), and mask-wearing (IRR 0.40, 95% CI 0.17–0.93).

Results of the multivariate analysis are shown in Table 3. Significant factors associated with being a case were being a high-risk close contact of the primary case (adjusted incidence rate ratios (AIRR) 5.36, 95% CI 2.22–12.94), bedroom density (AIRR 2.42, 95% CI 1.14–5.15), and wearing a face mask (AIRR 0.32, 95% CI 0.13–0.80).

Table 3. Risk factors of being a COVID-19 case in the football academy (Poisson regression)

Factors	Exposure		Non-exposure		IRR (95% CI)	AIRR (95% CI)
	cases	non-cases	cases	non-cases		
Female	27	32	21	96	3.57 (2.01–6.31)	2.57 (0.99–6.72)
Age >15 years	13	43	35	85	0.74 (0.39–1.41)	-
High-risk close contact of the primary case	20	8	28	120	7.85 (4.42–13.93)	5.36 (2.22–12.94)
Bedroom density >1.45 person/4 m^2	35	97	13	31	0.74 (0.33–1.68)	2.42 (1.14–5.15)
Wearing a face mask	42	122	6	6	0.40 (0.17–0.93)	0.32 (0.13–0.80)
Distancing	47	125	1	3	1.10 (0.15–7.95)	-
Hand washing before touching environment and others	45	124	3	4	0.52 (0.16–1.67)	-
Hand washing after touching environment and others	46	123	3	6	0.77 (0.24–2.47)	-
Dining with others	31	78	15	49	1.31 (0.71–2.43)	-
Sharing drinking glasses	32	67	16	61	1.73 (0.95–3.16)	1.78 (0.95–3.34)
Sharing spoon and folk	15	33	33	95	1.29 (0.70–2.38)	-
Buying delivery food	34	74	12	53	1.92 (0.99–3.70)	-
Go outside training camp	8	16	40	112	1.35 (0.63–2.89)	-

IRR: incidence rate ratios, AIRR: adjusted incidence rate ratios

Discussion

A cluster of COVID-19 cases in a football academy at a school in Buri Ram Province was confirmed. The overall attack rate was 22.4%. All cases were football players and the median age was 14 years. Females had a higher specific attack rate than males (45.8% versus 17.5%). A previous study showed no significant gender differences in susceptibility to COVID-19 infection.[19] Our study found that females had a higher specific attack rate, which was likely because the initial infection occurred among the female football players. Additionally, we investigated and provided control measures when the disease initially spread among the males.

Most cases were symptomatic; the most common symptoms being cough, sore throat, and fever. Symptoms of COVID-19 differ between studies.[9,20,21] The proportion of asymptomatic children and young people ranges from 14.6% to 42% based on a systematic review, and the most common symptoms are fever (46–64.2%) and cough (32–55.9%) with sore throat being less common.[9] A study from the United Kingdom reported that the most common symptoms in children aged 12–17 years were headache (65.9%), fatigue (60.7%), sore throat (51.0%), anosmia (48.3%), and fever (34.6%).[20]

The primary case was a female football player who developed symptoms on 7 October, two days before any other players became symptomatic. The source of infection for this local outbreak was unknown. Two asymptomatic cases had COVID-19 detected with a high cycle threshold value after the primary case was detected. We only used a single RT-PCR for diagnosis testing; therefore, we could not be certain that they had a prior or recent infection.[22] The serial trend of cycle threshold values can predict likely individual infectiousness.[23]

The lack of staff awareness contributed to the delay in outbreak detection and control. Additionally, we found that this cohort had close physical activities with each other, and personal protective equipments were not used, which may have contributed to disease spread.[24] Environmental factors may also have contributed to the spread of disease since the bedrooms were poorly ventilated and over-crowded.[16,17,25] The football academy did not follow the Department of Health's recommended measures for schools[5] or sports venues.[6,7] All bedrooms were over-crowded due to their crowd density more than one person per four square meters (m^2).[26] We found that among female bedrooms, density was positively related to the attack rate. Airflow rate, ventilation rate, and ACH were not associated with attack rate in this study, probably because we measured these parameters when all bedrooms were ventilated. Usually, the bedrooms at this academy were closed with no air ventilation, although air-conditioners would be operating, therefore ventilation rate and air change rate per hour was very low. We recommended to the staff at the academy that the ACH value should be at least 4.0 and the air ventilation rate should be more than 10 liters/second/person (36 m^3/hr per person).[26,27] Because all bedrooms had a density of more than the recommended value (less than 1 person/4 m^2), we defined a crowded bedroom as a bedroom that had a density of more than 1.45 person/4 m^2 for determination of risk factors.[26] The operative cut-off value was designed to find a recommended value that could be applied in this or similar settings.

Risk factors of being a COVID-19 case in the football academy on multivariate analysis were being a high-risk close contact of the primary case, bedroom density (>1.45 person/4 m^2), and lack of mask-wearing. A previous cohort study identified a higher secondary clinical attack rate and seroprevalence in household contacts than workplace contacts and social connections.[28] In this academy, football players lived in shared bedrooms, which were more like household settings. Also, close physical proximity is a known risk factor for SARS-CoV-2 transmission. In the bedrooms, the distance between beds was less than 0.5 meters, making it difficult to adhere to physical distancing and avoid direct conversation. Among the mask-wearing group, mask-wearing reduced 68% of COVID-19 cases that would occur if those did not wear masks.[29] Non-N95 type masks can also reduce the risk of infection and disease.[30]

Limitations

Our study has a few limitations. First, behavior and risk factor information was self-reported, which can introduce information bias. Second, ventilation measures did not suit this outbreak situation; thus, we could not provide more details about the association between air ventilation and COVID-19 infection in this outbreak. Third, confirmed cases with high cycle threshold levels (>30) diagnosed early in the outbreak did not receive a follow-up test, therefore we could not differentiate between prior and recent infection. Lastly, we did not identify the virus variants.

Recommendations

Sports academies and schools should encourage mask-wearing during an outbreak, ensure that rooms, especially bedrooms, have a density of less than 1.45 person/4 m^2, and provide isolation or quarantine rooms.

Conclusion

We report a cluster of COVID-19 cases in a football academy at a school in Buri Ram Province, Thailand, between September and November 2021, comprised of 48 confirmed cases (attack rate 22.4%). The source of this outbreak could not be identified. The risk factors of being a case were being a high-risk close contact of the primary case and over-crowded bedrooms. Mask-wearing was a protective factor.

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Knowledge, Attitude, and Self-reported Practices on Prevention of Respiratory Infections among Two Groups of Islamic Pilgrims, Thailand, 2021

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Abstract

Religious mass gatherings can foster contagious disease transmission in the home countries of pilgrims. Thailand has two major Muslim pilgrims: the Hajj and the Dawah. This study aimed to compare their knowledge (K), attitude (A), and self-reported practice (P), and qualitatively evaluate their perceptions regarding the prevention of respiratory infections. A cross-sectional mixed methods study was conducted. Multistage sampling was conducted in Hajj participants, while convenience sampling was used with the Dawah participants at two gathering places. Pearson's chi-square test was used to compare KAP scores between the two groups. We conducted qualitative interviews with 13 purposively chosen participants. There were 111 Hajj and 228 Dawah participants. Most Hajj respondents were in the age group of ≥50 years, while most Dawah respondents were between 30–49 years. Overall, the Hajj group had a significantly higher proportion of good knowledge scores than the Dawah group, with 76.6 and 56.1, as well as the positive attitude score of 97.3 and 87.7. The Hajj group was more receptive to receive health education about respiratory infections before their pilgrimage. Preparatory education classes should be initiated for Dawah Muslims before they attend a foreign gathering event.

Keywords: mass gatherings, respiratory infections, health education, perception, Thailand

Introduction

A mass gathering has been defined by the World Health Organization as an occasion, either by spontaneous accumulation or organized gatherings, where the number of people attending is sufficient to strain the planning and utilization of resources by the host.[1] The World Health Organization is concerned about mass gatherings as they have a tendency to increase the spread of infectious diseases, particularly coronavirus disease 2019 (COVID-19) cases.[2]

An example of a mass religious gathering is the Hajj, when approximately two million Muslims from all over the world travel to Mecca in Saudi Arabia each year.[3] Another specific group of Muslims, the Dawah Tablighi, who are similar to missionaries, are known to arrange religious mass gatherings several times in a year in various countries in South Asia.[4] In Thailand, most members of the Hajj and Dawah groups reside in the south of Thailand in Pattani, Yala, and Narathiwat Provinces, where they constitute 43.8% of all Hajj Thais and 80.0% of all Dawah Thais.[5]

A previous report by the Office of Disease Prevention and Control (Region 12) showed that, during the first wave of the COVID-19 outbreak in Thailand, about 42.0% of all COVID-19 cases in the three southernmost provinces, namely Pattani, Yala, and Narathiwat, were imported from attendees of Dawah events outside Thailand.[6] Therefore, it is crucial to assess the level of knowledge (K), attitude (A), and self-reported practice (P) regarding respiratory infections among the Hajj and Dawah Muslims. This study aimed to compare their KAP level and qualitatively evaluate their perceptions regarding the prevention of respiratory infections.

Methods

We used a mixed method approach composed of quantitative and qualitative studies. A semi-structured questionnaire was used for data collection. The inclusion criteria were Thai Muslims aged 18 years or above, who could read Thai or Yawi language and had ever attended overseas Hajj in 2019 or Dawah events between 2015 and 2019. Those who had ever attended both events were excluded.

Quantitative Study

We purposively selected two districts in each of Pattani, Yala, and Narathiwat Provinces. For the Hajj group, we used simple random sampling with proportionate to size using a sampling frame from a list of Thai Hajj participants in 2019. For the Dawah group, we selected participants from those who attended weekly local gathering events at the two prominent mosques of the Dawah group. Then, we categorized the participants according to their domicile province, and conveniently chose participants proportionately to the volume of Muslim population.

We determined the sample size using two independent proportions comparison formula with a level of statistical significance of 0.05. An initially estimated proportion of good knowledge level among Hajj and Dawah participants was 80% and 65%, respectively. Therefore, 115 Hajj and 229 Dawah members were required.

We collected the data using a self-administered paper-based questionnaire which was validated by experts, such as respiratory physician, epidemiologist, health educators, the spiritual leader of the Dawah Tablighi group, and the chief of the Thailand Hajj Medical Office. The item-objective congruence score was 0.7. The questionnaire was piloted and the Cronbach's coefficient alpha for knowledge, attitude, and reported practice equaled 0.96, 0.81, and 0.72, respectively, with an acceptable cutoff $\geq$0.7.[7]

The participants' socio-demographic characteristics were analyzed using frequency and percentage. The participants' KAP (Knowledge, Attitude and Practice) level was assessed through five sub-domains: infectious respiratory diseases, wearing a mask, hand washing, vaccines, and contact avoidance behaviors. The infectious respiratory diseases sub-domain was evaluated only knowledge and attitude. In total, there were 53 questions with 24 focused on knowledge (K), 16 on attitude (A), and 13 on practice (P). Bloom's cutoff point was used to define "good" or "poor" scores.[8,9] Knowledge scores of $\geq$14 ($\geq$60%) were considered as good, while scores <14 were considered poor. Attitude scores of $\geq$51 ($\geq$80%), 38–50 (60–79%), and <38 ($\leq$59%) were defined as positive, neutral, and negative, respectively. Practice scores of $\geq$29 ($\geq$80%) were considered good, while scores <29 were considered poor. Pearson's chi-square test was used to compare the KAP level between the two groups, the Hajj group and the Dawah group. Weight calculations were used to adjust for the size of the source populations of about 3,300 and 5,000 people among the Hajj group and the Dawah group, respectively.

Qualitative Study

We purposively selected 13 participants, 5 Hajj participants and 8 Dawah participants. First, we recruited two Dawah spiritual leaders to explore their perception toward respiratory infection prevention practices among the followers. Then, six participants of the Dawah group and five participants of the Hajj group were recruit for interview.

We used semi-structured in-depth interviews. The interview focused on the perception of respiratory infections and their prevention practices while they were at the gathering events. Thematic analysis was conducted. Important quotes for each theme were collated and reviewed.

Ethics

This study was approved by the Human Research Ethics Committees from each Provincial Health Office in the three southernmost provinces with research codes 27/63 (Narathiwat Province), 38/63 (Pattani Province), and 01/64 (Yala Province). The research protocol strictly followed international standards. All participants provided consent for joining the study and were given a study information sheet.

Results

Quantitative Study

Of 344 participants enrolled in the study, 339 (111 Hajj and 228 Dawah participants) returned the questionnaire (response rate 98.5%). The overall male to female ratio was 2.8:1. The Hajj group had a median age of 55 years, while the Dawah group had a median age of 43 years. Most participants in both groups were self-employed (41.4% in the Hajj group and 58.8% in the Dawah group). Most of the Hajj group had completed secondary school (36.9%). However, most of the Dawah group achieved at most a primary school level of education (39.9%). About one fifth of the Hajj group had a monthly income of more than 20,000 Thai baht. About 3.9% of the Dawah group had a monthly income of more than 20,000 Thai baht (Table 1).

Table 1. Characteristics of the study participants of knowledge, attitude, and self-reported practices on prevention of respiratory infections among two groups of Islamic pilgrims, Thailand, 2021 (n=339)

Variables	Frequency n (%)			*P*-value
	Total (n=339)	Hajj group (n=111)	Dawah group (n=228)	
Gender				
Male	250 (73.8)	48 (43.2)	202 (88.6)	<0.01
Female	89 (26.3)	63 (56.7)	26 (11.4)	
Age group (years)				
18–29	37 (10.9)	0 (0)	37 (16.2)	<0.01
30–49	123 (36.3)	22 (19.8)	101 (44.3)	
≥50	179 (52.8)	89 (80.2)	90 (39.5)	
Occupation				
Homemaker	24 (7.1)	15 (13.5)	9 (3.9)	0.03
Civil servant	19 (5.6)	12 (10.8)	7 (3.1)	
Self-employed	180 (53.1)	46 (41.4)	134 (58.8)	
Student	26 (7.7)	0 (0)	26 (11.4)	
Farmer	75 (22.1)	31 (27.9)	44 (19.2)	
Highest formal education level				
None	33 (9.7)	13 (11.7)	20 (8.8)	0.10
Primary school	123 (36.3)	32 (28.8)	91 (39.9)	
Secondary school	122 (35.9)	41 (36.9)	81 (35.5)	
Vocational certificate	16 (4.7)	4 (3.6)	12 (5.3)	
Bachelor's degree or above	45 (13.3)	21 (18.9)	24 (10.5)	
Monthly income (baht)				
<5,000	120 (35.4)	41 (36.9)	79 (34.6)	0.03
5,000–10,000	144 (42.4)	35 (31.5)	109 (47.8)	
10,001–20,000	43 (12.7)	14 (12.6)	29 (12.7)	
>20,000	29 (8.6)	20 (18.0)	9 (3.9)	

Table 2 presents a comparison of the KAP levels between the two groups. From a macro-view, 76.6% of the Hajj group and 56.1% of the Dawah group had good knowledge. A significant difference between the groups was found in overall knowledge in terms of mask wearing, hand washing, and contact avoidance. Almost all Hajj participants (97.3%) had either neutral or positive attitudes for all sub-domains combined, and the percentage was significantly higher than that for the Dawah group (87.7%). In all sub-domains except for contact avoidance, the percentage of Hajj participants showing either neutral or positive attitudes was significantly higher than that in the Dawah group. The percentage of participants with a neutral or positive attitude towards contact avoidance was similar between the two groups. For self-reported practice, about half of the Hajj participants (52.3%) showed good practice for overall, compared to 42.9% among the Dawah participants. The percentage of Hajj participants reporting good practice was higher than the percentage of the Dawah participants in terms of mask-wearing (p-value <0.05) and vaccination (p-value <0.01).

Table 2. Comparison of knowledge, attitude and self-reported practice levels regarding respiratory infection and preventive practices between Hajj and Dawah participants (n=339)

	Frequency n (%)								
	Good knowledge			Neutral to positive attitude			Good practice		
	Hajj (n=111)	Dawah (n=228)	*P*-value	Hajj (n=111)	Dawah (n=228)	*P*-value	Hajj (n=111)	Dawah (n=228)	*P*-value
Overall	85 (76.6)	128 (56.1)	0.04	108 (97.3)	200 (87.7)	<0.01	58 (52.3)	98 (42.9)	0.78
Sub-domain									
Infectious respiratory diseases	76 (68.5)	120 (52.6)	0.12	28 (25.2)	27 (11.8)	<0.01	NA	NA	NA
Mask wearing	96 (86.5)	144 (63.2)	<0.01	110 (99.1)	205 (89.9)	<0.01	40 (36.0)	55 (24.1)	<0.05
Hand washing	95 (85.6)	146 (64.0)	<0.01	110 (99.1)	190 (83.3)	<0.05	90 (81.1)	181 (79.4)	0.92
Vaccination	83 (74.8)	137 (60.1)	0.09	91 (81.9)	143 (62.7)	<0.05	101 (90.9)	144 (63.2)	<0.01
Contact avoidance	86 (77.5)	126 (55.3)	<0.01	107 (96.4)	191 (83.8)	0.05	55 (49.6)	114 (50.0)	0.24

NA: not applicable

Qualitative Study

We found four main themes from the interview.

Different perspectives about respiratory infections

Five out of eight Dawah interviewees said that respiratory infection was caused by viral pathogens, and two said that the infection was caused by other factors such as weather changes. All Hajj interviewees said that viral pathogens were likely to be the cause of respiratory infections. The Hajj interviewees also raised concerns about the negative consequences of respiratory infection as it might disturb the Hajj ritual.

"During the event, a lot of people got cold due to weather change." …Dawah, A1

"We believe that respiratory symptom is the test of mankind." …Dawah, A2

"I don't want to get a cold…. it makes me cough and gives me muscle pain so much that I could not perform my worships during the Hajj" …Hajj, B1

Careless practices and misconceptions of preventive behavior

All Dawah interviewees said that they were not familiar with mask wearing. For the Hajj group, three out of five interviewees did not wear a face mask all the time, but they used it when facing unfamiliar groups of people or unfavorable environments.

"It is rare that someone wears a mask during a gathering" …Dawah, A1–A6

"I wore a mask just while walking through a group of strangers." …Hajj, B2

"I wore a mask to protect myself from dust." …Hajj, B3 and B4

Ignorance of washing hands outside of prayer times

Regarding hand-washing perceptions, nine out of 13 interviewees from both groups mentioned that hand washing was usually done before daily prayers, but they did not use soap after touching ill people or commonly used objects, and after coming back from the outside.

"We wash our hands five times before praying" …Dawah, A1–A7

"Washing hands five times before praying is enough" …Hajj, B3 and B5

Conflict of trust and the necessity of vaccinations

There were differing opinions on pre-travel vaccination. Some Dawah participants highlighted the benefit of receiving vaccines. However, four Dawah participants expressed doubts about vaccination, whether it met the halal standards. Hajj interviewees said that the vaccines were acceptable, and vaccination was a prerequisite for performing the Hajj in Mecca.

"I doubt the ingredients of the vaccine, whether it is halal and safe." …Dawah A2, A5–A7

"We must be vaccinated, or we will not be allowed to perform the Hajj." …Hajj, B3

Discussion

This study is, to our knowledge, the first to explore the knowledge, attitude, practices and perceptions related to respiratory infections among two different groups of Thai Muslims. We found that the Hajj participants, in general, had a significantly higher level of knowledge and more positive attitude toward respiratory infection prevention than the Dawah group, especially for mask-wearing, hand washing and contact avoidance.

The Dawah group had a lower level of knowledge on the prevention of respiratory infections than the Hajj group, which is likely explained by the fact that most of the Dawah participants had never been informed about respiratory infections before traveling abroad to Dawah events. While most of the Hajj people received pre-travel healthcare training at a Hajj clinic that provided pre-departure health education, vaccination, and health assessment.[5,10] Our finding was supported by a previous study among Australian Hajj pilgrims, which revealed that pre-departure health education interventions were beneficial in promoting travelers' preventive practices.[11]

A low rate of mask wearing among the two groups was found. This might be because most of the participants did not view respiratory symptoms as a sign of infection. They mostly viewed these as an allergic reaction related to changes in the weather. They wore a mask only when walking through unfamiliar groups of people or for protecting them from a dusty environment.

The proportion of participants with neutral or positive attitude and good level of practice toward pre-departure vaccination was significantly lower in the Dawah group than in the Hajj group. This finding was consistent with the qualitative results that some participants distrusted vaccines or were not confident in being vaccinated. A previous study in the three southernmost provinces of Thailand reported that residents demonstrated conflicting attitudes towards disease prevention by vaccination due to distrust of ingredients in vaccines that may not be Halal (Islamic religious permission) and may be against the principle of Islam as bringing a part of the disease into the body.[12–15] The advice on the usefulness and necessity of vaccination, especially during the pre-departure period, should be emphasized as a previous study suggested that pre-travel advice was twice as likely to contribute to vaccination, compared with the absence of this advice.[11]

Limitations

There are some limitations in this study that should be acknowledged. First, memory bias is inevitable as we asked the participants about their past experiences. However, these religious gatherings were the most important events in a Muslim's life, and most participants joined this important event only once in their lives. Therefore, memory bias may be minimal and may not affect the validity of our results. Second, selection bias could have occurred, especially in the Dawah group due to convenience sampling. Hence, the representativeness of our results is likely to be undermined. Although there is no information on population characteristics to be used for verifying the representativeness of the sample, other characteristics of the Dawah participants in this study, including age, occupation, education, and income, are essentially diverse and not clustered in any narrowly specific group. This result implies that the inferential statistics used in this study would be conceptually applicable, based on the concept of the superpopulation model, to understand more about this dynamic and relatively hard-to-reach population.[16]

Public Health Actions and Recommendations

The Thai Ministry of Public Health should collaborate with the National Islamic Authority of Thailand to involve religious leaders of the Dawah Tablighi to establish a registration system for travelers journeying abroad to Dawah events. The travelers should coordinate with the healthcare providers in their residential areas to organize pre-travel health training, check-ups, and vaccinations. Participants of these Dawah events should receive health education and health assessment similar to the Hajj travelers. Intensive vaccination campaigns should be conducted and the campaign message should be tailored to match the perceptions of the Thai Muslims in order to have them realize the benefits of vaccination and reassure them that it does not violate halal laws or regulations.[13,15]

Conclusion

Hajj Muslims had better knowledge and attitudes towards prevention of respiratory infections than their Dawah counterparts. Dawah travelers to foreign countries should be considered as a target group for health education. Pre-travel clinics for Dawah Muslims should be set up in all district hospitals.

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Gastroenteritis Outbreak of Rotavirus G3P[8] in a Secondary School in Pathum Thani Province, Thailand, 2022

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Abstract

On 14 Sep 2022, the Division of Epidemiology was notified of a cluster of food poisoning in a secondary school. We conducted an investigation to describe the epidemiological characteristics of the outbreak, identify the causative agent, source of illness, and possible risks, and provide control measures. An electronic-based questionnaire was distributed to school members. Students and staff were interviewed. Inspection of the school canteen, water supply system, toilets, and hand-washing facilities as well as observation of personal and food hygiene practices among food handlers were done. A retrospective cohort study was conducted. The overall attack rate was 40.4% (684/1,695). Most cases were students (95.9%). Thirteen out of twenty-eight rectal swabs were positive for rotavirus, with two being identified as genotype G3P[8]. Being exposed to foods or drinks from the school canteen was a significant risk factor (adjusted odds ratio (AOR) 2.35, 95% CI 1.23–4.52), and bringing a drink to school was protective (AOR 0.67, 95% CI 0.50–0.88). Although rotavirus was not detected in the environment, contamination of groundwater used for cooking and drinking was evident. We recommend routine water quality testing and installation of groundwater treatment to ensure the safety of the water supply.

Keywords: rotavirus, food poisoning outbreak, school, groundwater

Introduction

Group A rotavirus infection is one of the leading etiologies of acute gastroenteritis worldwide. The World Health Organization reported that every year rotavirus infection causes more than 200,000 fatalities in children under the age of five years with 85% of deaths occurring in low-income countries in Asia and Africa.[1,2] In Southeast Asia, more than half of all diarrhea deaths were associated with rotavirus infection.[3]

Rotavirus is a non-enveloped, double-stranded virus belonging to the *Reoviridae* family. They can be classified into G-genotypes and P-genotypes based on capsid proteins.[4] About 90% of human group A rotavirus infections are caused by various combinations of five rotavirus genotypes (G1P[8], G2P[4], G3P[8], G4P[8], and G9P[8]).[5,6] Only rotavirus genotype G9 is associated with increased severity of diarrheal disease but the evidence remains controversial.[7]

Two live-attenuated oral vaccines for rotavirus are available, namely Rotarix™ and RotaTeq™ and, since their introduction in 2006 and 2008, respectively, the prevalence of rotavirus-associated diarrhea has gradually declined worldwide.[8,9] Rotavirus vaccines, available for infants aged 6-32 weeks, have been part of Thailand's Expanded Program on Immunization since 2020.[10]

Classic presentations of rotavirus infection include fever, vomiting, and watery diarrhea. Children aged less than 5 years are at risk of severe dehydration.[10] In adults, however, symptoms and severity of rotavirus diarrhea varies. Asymptomatic carriers comprise up to almost 80% of infected adults.[11,12]

On 14 Sep 2022, the Division of Epidemiology was notified of a suspected food poisoning cluster of approximately 400 students in a secondary school in the Khlong Si Subdistrict, Khlong Luang District, Pathum Thani Province. A joint investigation was conducted during 15–16 Sep 2022 to identify the causative agent, source of illness, and possible risk factors, describe the epidemiological characteristics of the outbreak, and provide control and prevention measures.

Methods

Descriptive Study

We performed an active case finding and a descriptive study by distributing an electronic-based, self-administered questionnaire to all students and staff of the affected school. A list of hospitalized students and staff was obtained and in-depth interviews via telephone were conducted. Medical records of students and staff and infirmary records were reviewed. Information retrieved included demographic characteristics, clinical data, history of food and beverage consumption, and sanitation behaviors.

Our case definitions were as follows: suspected cases were students or staff who developed at least one of the following symptoms during 27 Aug to 21 Sep 2022: diarrhea, mucus in stool, stomachache, nausea, and vomiting. Confirmed cases were suspected cases who tested positive for gastrointestinal pathogens in stool or vomitus samples via bacterial culture or reverse transcriptase polymerase chain reaction.

Laboratory Study

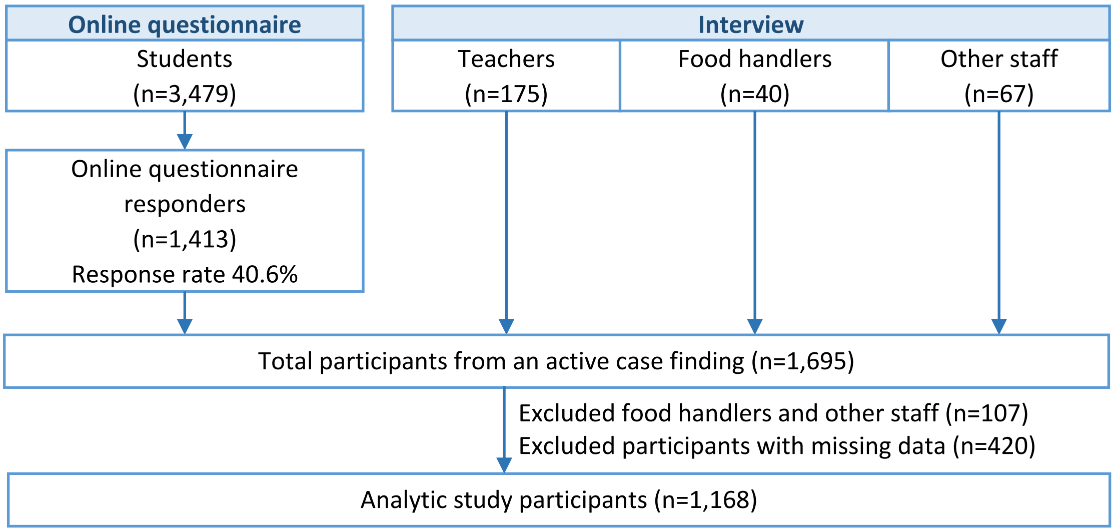
A total of 56 rectal swabs and fresh stool samples were randomly obtained from 26 suspected cases who were symptomatic on the days of specimen collection, as well as two food handlers who reported having diarrhea within the last month. Hand swabs of food handlers and swabs from canteen equipment were also obtained. Cary Blair transport media and universal transport media were used for bacterial and viral testing, respectively. In addition, we collected samples of water from a drinking fountain, bottled drinking water, cooking water used in the school canteen, water from storage tanks and groundwater wells, and ice for consumption and for food storage. All specimens were sent for enteropathogenic bacterial culture and reverse transcriptase polymerase chain reaction for norovirus and rotavirus at the National Institute of Health of Thailand. Some of the positive human specimens were then sent for genotype identification by the Sanger sequencing method at the National Institute of Health of Thailand.[13]

Environmental Study

The dining and cooking areas of the school canteen, the school water supply system, toilets, and hand-washing facilities were inspected. We observed the food preparation and serving processes, food and raw material storage in the canteen, and student's eating and hygiene habits of students. Food handlers were asked about their history of illness in the past month, source of raw ingredients, and cooking processes. The canteen manager, canteen janitors, and the school premises manager were also interviewed. Hands of food workers, selected food items, and kitchen surfaces were tested for coliform bacteria using an SI-2 test kit.

Analytic Study

A retrospective cohort study was conducted. We employed the census method of data collection. The main exposure of interest was a history of food or beverage consumption in the canteen. The non-exposure group included persons who did not buy food or drink from the canteen from 27 Aug 2022 to the investigation day. Covariates included gender, age, occupation, and sanitation behaviors. Cases were defined as either suspected or confirmed based on our descriptive study and non-cases were participants who did not meet the criteria for either. We recruited all students and teachers in the school into the study cohort. Those who failed to respond to the questionnaire or had missing data on the history of food and beverage consumption or sanitation behaviors were excluded. Sample size calculation was performed using the formula for comparing two proportions for a cohort study.[14,15] The following parameters were applied; type I error=5%, power=80%, probability of an outcome in the exposed group=41%, probability of an outcome in the unexposed group=18.7%, and relative risk (RR)=2.18 based on a previous study.[16] The required number of study subjects was 65 in the exposed group and 65 in the unexposed group. Univariable and multivariable logistic regression models were used to determine factors associated with being a case. Known risk factors from the literature and variables with a *p*-value less than 0.2 from the univariable analysis were included in the multivariable analysis. Crude RR, adjusted odds ratio (AOR), *p*-value, 95% confidence interval (CI), and population attributable fraction (PAF) for stores and food items were calculated. *P*-values less than 0.05 were considered statistically significant. We used R version 4.2.1 for statistical analysis.



Some teachers were respondents of the online questionnaire as well as being interviewees.

Figure 1. Recruitment of participants in a food poisoning outbreak in a secondary school, September 2022

Results

Setting

The affected school is located in the Khlong Si Subdistrict, Khlong Luang District, Pathum Thani Province. It comprises 3,479 students, 175 teachers, 40 food handlers, and 67 non-teaching staff. There is one school canteen for everyone in the school, which is open during lunch time.

Descriptive Study

Of all school members, 1,413 students and 282 staff were either interviewed or responded to our questionnaire. The response rate was 40.6% among students (Figure 1). A total of 684 cases (651 suspected cases and 33 confirmed cases) were identified, given an overall attack rate of 40.4% (684/1695). Of these, 656 (95.9%) were students and 294 (43.0%) were male. The median (interquartile range) age of cases was 15 (14–17) years. The attack rate was highest among students (46.4%) (Table 1). Cases were closely distributed across student grades and classes. The grade-specific attack rates ranged from 37.4–52.8% (Table 2). Most cases lived in Pathum Thani Province (92.8%) and about half resided in Khlong Luang District (48.7%).

Table 1. Attack rates of the food poisoning outbreak in a secondary school during September 2022, by occupation (n=1,695)

Occupation	Total population	Suspected case	Confirmed case	Attack rate (%)
Student	1,413	636	20	46.4
Teacher	175	14	7	12.0
Food handler	40	-	2	5.0
Others	67	1	4	7.5
Total	**1,695**	**651**	**33**	**40.4**

Table 2. Attack rates of the food poisoning outbreak among students of a secondary school during September 2022, by grade (n=1,393)

Grade	Case no./total no.	Attack rate (%)
7	94/197	47.7
8	93/206	45.1
9	102/273	37.4
10	116/221	52.5
11	86/163	52.8
12	145/333	43.5

The grade data of twenty students were missing.

Twenty-four percent of the cases went to hospital and 25 were hospitalized. All cases had mild-to-moderate dehydration and there were no serious complications or deaths. The most common symptoms were diarrhea (85.0%), stomachache (79.0%), vomiting (64.5%), fever (57.1%), and nausea (49.9%) (Figure 2).

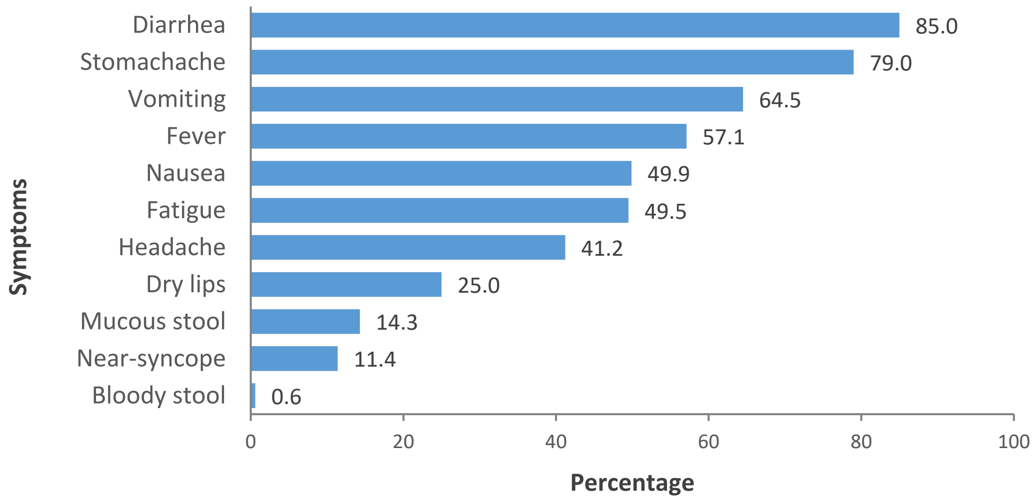


Figure 2. Frequency of symptoms among food poisoning cases in a secondary school, September 2022 (n=684)

Figure 3 shows the epidemic curve, which indicated a mixed source pattern. Out of 684 cases, 42.11% (288/684) of the data was missing due to the absence of onset time. A few cases developed symptoms on 1 Sep 2022. The number of cases increased rapidly on 11 September and peaked on 11 Sep 2022. The onset of the last known case was 17 Sep 2022. No common school events or sports activities were held before the outbreak. However, there was heavy rain on the afternoon of 8 Sep 2022 and parts of the Khlong Luang District were flooded. A school examination was held from 12–19 Sep 2022, during which half the students came to school each day. A school holiday occurred from 20 Sep to 27 Oct 2022.

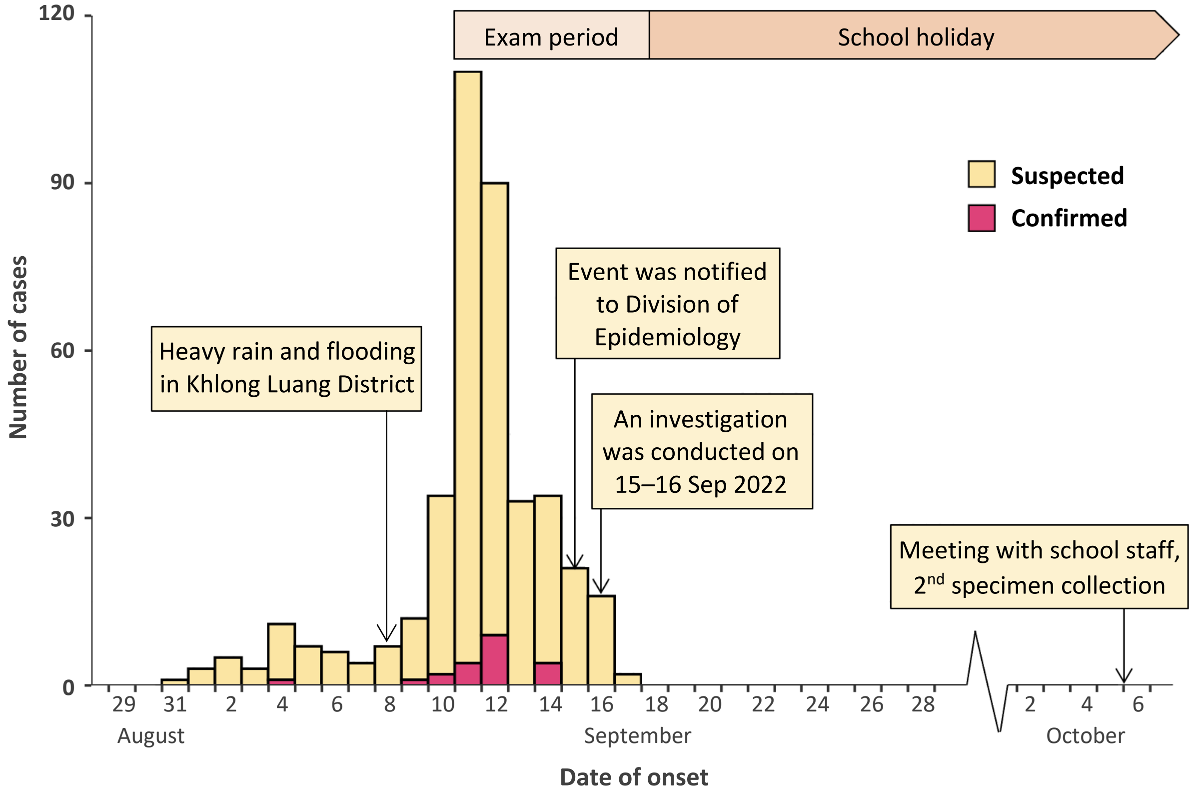


Figure 3. Epidemic curve of a food poisoning outbreak in a secondary school, September 2022 (n=396)

Analytic Study

A total of 1,168 participants (1,137 students and 31 teachers) were included in the analysis. From univariable analysis, the relative risks and PAF by stores (21 stores in total with varying types of food sold in each store, such as noodle soup and rice) and by food items were very similar, ranging from 0.83–1.31 and 0–16.34%, respectively. With this reason, we then hypothesized that there was a common exposure in the school canteen. Therefore, we grouped all stores into one variable, namely "overall exposure to foods or drinks from the canteen" between 27 Aug 2022 and 16 Sep 2022. Overall exposure to foods or drinks in the canteen was a significant risk factor with an AOR of 2.35 (95% CI 1.23–4.52), PAF of 55.48% (95% CI 17.51–76.46), and the attributable number of cases was 379. Exposure to any foods and to any drinks in the canteen had AOR of 2.38 (95% CI 1.29–4.38) and 1.26 (95% CI 0.95–1.67), respectively. Bringing one's own lunch, bringing one's own drink, and bringing one's own utensils were significant protective factors from the univariable analysis. After adjusting for covariates, bringing one's own drink (AOR 0.67, 95% CI 0.50–0.88) remained the only significant protective factor (Table 3).

Table 3. Univariable and multivariable analysis of factors associated with food poisoning among students and teachers in a secondary school during September 2022 (n=1,168)

Variables	Crude RR (95% CI)	Adjusted OR (95% CI)	*P*-value	% PAF[a] (95% CI)
Male (vs. female)	0.97 (0.82-1.13)	0.99 (0.76–1.29)	0.942	NA (NA–10.63)
Age (cont. var)	-	1.02 (0.97–1.06)	0.519	-
Student (vs. teacher)	0.98 (0.61-1.59)	1.51 (0.36–6.37)	0.573	NA (NA–83.94)
Overall exposure to foods or drinks from the canteen	2.54 (1.52-4.22)	2.35 (1.23–4.52)	0.010	55.48 (17.51–76.46)
Washing hands before eating	0.88 (0.75-1.05)	0.92 (0.71–1.20)	0.549	NA (NA–9.16)
Bringing one's own lunch	0.37 (0.20-0.68)	0.55 (0.23–1.31)	0.174	NA (NA–1.96)
Bringing one's own drink	0.74 (0.62-0.87)	0.67 (0.50–0.88)	0.004	NA (NA–NA)
Bringing one's own utensils	0.58 (0.44-0.77)	0.67 (0.42–1.07)	0.096	NA (NA–1.22)

RR: Relative risk, OR: Odds ratio, PAF: Population attributable fraction, CI: Confidence interval

[a]Negative values are denoted as NA.

Laboratory Study

Thirteen out of twenty-eight stool specimens from suspected cases (11 from students and teachers, and 2 from symptomatic food handlers) were positive for rotavirus. An additional 14 suspected cases who visited hospitals also reported that they tested positive for rotavirus. Rotavirus G3P[8] was confirmed in the suspected cases and food handlers. Other pathogens found in fecal matters of the cases included norovirus, *Staphylococcus aureus, Bacillus cereus, Vibrio cholera non-O1, Plesiomonas shigelloides,* and *Aeromonas* spp. (Table 4). Similar enteropathogenic bacteria were presented in hand swabs of food handlers, water from various sources, ice specimens, and some environmental swabs. To re-assess water contamination, we collected groundwater specimens from the school three weeks after the initial investigation. The pathogens identified were comparable to the ones obtained from the samples collected initially.

Table 4. Gastrointestinal pathogens isolated from food poisoning among students and teachers, food handlers, water, ice, and environmental specimens in the school, September 2022

Source	Bacterial culture		Viral RT-PCR	
	No. of isolates (samples)	Pathogen (n)	No. of isolates (samples)	Pathogen (n)
Students and teachers (stool samples and rectal swabs)	6 (26)	*S. aureus* (3) *B. cereus* (2) *V. cholera* non-O1 (1) *P. shigelloides* (1) *Aeromonas hydrophila* (1) *Aeromonas veroii* (1)	11 (26)	Rotavirus G3P[8] (1) Rotavirus, untyped (10) Norovirus
Food handlers[a] (stool samples)	1 (2)	*P. shigelloides* (1)	2 (2)	Rotavirus G3P[8] (1) Rotavirus, untyped (1)
Food handlers (hand swabs)	2 (3)	*B. cereus* (1) *Aeromonas* spp. (1)	0 (3)	Tested negative
Water for cooking[b]	1 (1)	*Aeromonas* spp. (1)	0 (1)	Tested negative
Water from storage well	1 (1)	*B. cereus* (1) *Aeromonas veroii* (1)	0 (1)	Tested negative
	1 (1)[d]	*B. cereus* (1) *Aeromonas hydrophilla (1)*	0 (1)	Tested negative

Table 4. Gastrointestinal pathogens isolated from food poisoning among students and teachers, food handlers, water, ice, and environmental specimens in the school, September 2022 (cont.)

Source	Bacterial culture		Viral RT-PCR	
	No. of isolates (samples)	Pathogen (n)	No. of isolates (samples)	Pathogen (n)
Groundwater well no.1[c]	1 (1)	*B. cereus* (1)	0 (1)	Tested negative
	1 (1)[d]	*B. cereus* (1) *Aeromonas caviae* (1) *Aeromonas veronii* (1)	0 (1)	Tested negative
Groundwater well no.2	1 (1)[d]	*Aeromonas veronii* (1)	0 (1)	Tested negative
Drinking fountain	1 (2)	*B. cereus* (1)	0 (2)	Tested negative
Bottled water	0 (1)	-	0 (1)	Tested negative
Ice for food storage	2 (2)	*Salmonella* spp. (1) *E. coli* (1) *B. cereus* (1) *P. shigelloides* (1) *Aeromonas hydrophila* (2) *Aeromonas veroii* (2)	Not sent	Tested negative
Ice for consumption	Not sent	-	0 (2)	Tested negative
Utensil swabs	0 (2)	-	0 (2)	Tested negative
Dish swabs	0 (2)	-	0 (2)	Tested negative
Swabs from cooler boxes	2 (2)	*Aeromonas veroii* (1) *Aeromonas caviae* (1) *Aeromonas* spp. (1)	0 (2)	Tested negative
Swabs of canteen water tap	1 (1)	*Aeromonas caviae* (1)	0 (2)	Tested negative
Swabs of drinking fountain	0 (1)	-	0 (1)	Tested negative

[a]Collected from symptomatic food handlers only
[b]Collected from water tap in school canteen
[c]Groundwater well which supplied school canteen
[d]Results from specimen collection on 6 Oct 2022

Environmental Study

The physical structure of the canteen complied with hygiene standards issued by the Thai Department of Health, Ministry of Public Health. We observed no insects or pests upon investigation. Handwashing facilities (a sink with tap water and soap provided) were present. However, based on our interview, soap was not always available, and some students were not aware of the handwashing area in the school canteen. The annual inspection of the canteen by the local public health authorities was interrupted due to the COVID-19 pandemic during the last two years.

Some food sold in the canteen was pre-cooked by food handlers at their homes and brought to school each morning. Raw ingredients were bought from nearby local markets twice a week and stored at the homes of the food handlers. Water from a faucet in the canteen was used directly for cooking and preparing beverages. Some raw materials were stored in the same container where ice for consumption was kept. From the SI-2 test, 73.5% (25/34) of hand swabs from food handlers, 50.0% (8/16) of food items, and 20.0% (1/5) of utensils and dish swabs tested positive for coliform bacteria.

Most food handlers wore a mask and hair covering at all times. Some food handlers used their bare hands to prepare and serve food. Two of the food handlers from the same noodle shop reported a recent history of diarrhea and both came to work on the days of illness. All food handlers were required to submit a health check-up certificate to the canteen manager every year; however, we were unable to verify this on the days of inspection.

Groundwater was the main water supply in the school. There was no groundwater treatment system in place. The groundwater well, which provided water supply for the school canteen, is located near a cesspool and sewer pipes. Gross contamination of water was observed in the water tanks. Most students drank bottled water sold by the school, although there were drinking fountains where water was supplied from the provincial waterwork. The free residual chlorine level in pre-filtered water was 0.04 parts per million, which was lower than the recommended standard.[17] Ice for all stores in the canteen is supplied daily from an ice factory in the province.

Actions Taken

A meeting with school staff was held and a school renovation plan was developed. Groundwater wells were immediately shut down. The water supply in the school canteen was replaced by water from a drinking water factory. Symptomatic food handlers were not permitted to work until they tested negative for rotavirus. Daily case monitoring was done by school infirmary staff. Active surveillance of food poisoning and diarrhea clusters in high-risk spots (e.g., daycare centers and kindergartens) was conducted by the local authority. After school re-opening, the daily number of cases who developed food poisoning or acute diarrhea did not exceed two.

Discussion

We report a food poisoning outbreak in a secondary school in Pathum Thani Province, Thailand. From 1 Jan to 4 Nov 2022, 39 other food poisoning outbreaks were reported in Thailand, of which 18 (46.2%) occurred in the school setting. The overall attack rate in this outbreak was 40.4%, which was higher than the median attack rate of foodborne events reported in schools in Thailand in 2022 (27.7%, range 3.1–56.3%).[18] This event was one of the largest food poisoning outbreaks in Thai educational institutions.

The most likely causative agent of this outbreak was rotavirus G3P[8]. Though rotavirus vaccines have been added into routine immunization, most students were born prior to its availability. Studies showed genotype G3P[8] to be the most frequently detected strain of rotavirus in Thailand during 2016–2019 in both children and adults.[19,20] Although rotavirus is more prevalent among children, it is not uncommon for adults to be infected with the pathogen.[6,11] Clinical manifestations of rotavirus infection in adults can vary. The most common symptoms in a prior study were diarrhea, abdominal pain, and nausea, consistent with our findings.[21] Although other bacteria and viruses identified from human specimens were known to cause foodborne infection, they were less likely to be the main contributors of this outbreak as these pathogens were found in only a few cases and no clear evidence of their epidemiological linkage was identified. Co-infection was a possibility despite the very small number of cases (n=3) showing mixed organisms (rotavirus and other organisms).

Groundwater supplying the school canteen was the most probable source of this outbreak. Every store in the canteen used this water for cooking, which resulted in cross-contamination. Results of the analytic study showed that exposure to foods or drinks from the canteen was a significant risk factor. Attack rates and relative risks of food items and canteen stores were homogenous. Multiple enteropathogenic bacteria were detected in water specimens from groundwater tanks, a water storage well, and water taps in the canteen. These bacterial species were consistent with species found in the stool samples of cases. It was likely that the water was contaminated with human feces. Leakage of the cesspool or deterioration of sewage pipes is plausible. Previous rotavirus gastroenteritis outbreaks due to contamination of the water supply system of a hotel have been reported in Thailand.[12] Similar to our study, the hotel where the outbreaks occurred used unchlorinated groundwater from a well near a sewage pond for cooking and drinking.

Rotavirus can survive in freshwater for up to 10 days at 20°C and has a very small infectious dose (10–100 viral particles).[4,22] While groundwater use is not common nowadays in urban areas due to strict control by the government, in rural areas groundwater is often used as a primary source of drinking water.[23] This study highlighted the public health importance of routine quality testing and a treatment system for groundwater.

This outbreak was preceded by a period of heavy rain which resulted in flooding in the Khlong Luang District. During September–October 2022 Thailand suffered from its worst flood in many years.[24] Pathum Thani Province was also affected. The flooding may have contributed to the contamination of the water supply in the school. Floodwater was found to be associated with a higher concentration of enteric pathogens, specifically *Escherichia coli* and rotavirus group A.[25] Moreover, flooding is found to be a predisposing factor for rotavirus outbreaks, even in surrounding regions that might not be directly affected by the flood.[26]

Limitations

First, we were unable to obtain a full list of names and contact information of students due to privacy issues. Also, students were not available for interviews during the school examination period. We distributed an electronic-based questionnaire to all students and obtained an overall response rate of only 40.6%. Analytic results should be interpreted with caution as they might be subjected to non-response bias. Second, memory bias was possible as a nature of a retrospective study. Third, we were unable to detect rotavirus from water samples, probably because of the higher detection limit of the conventional PCR method. Fourth, the attack rate reported herewith was subject to overestimation as symptomatic cases were likely to respond to the survey than those with mild or no symptoms, not to mention the no-show school members. Fitfh, no leftover food was available for microbial testing on the investigation days. Lastly, most food handlers were unwilling to provide information about their history of illness within the past month and refused to provide consent for specimen collection.

Recommendations

We recommended that the school should cease using the groundwater supply until appropriate treatment systems are in place. The canteen manager should ensure that food handlers follow standard personal and food hygiene practices, e.g., storing raw materials and cooked food separately and separating ice for consumption from ice for food storage. Moreover, food handlers should always wear protective masks, hair covers, and gloves while handling food, and that they refrain from work while having an illness. Handwashing with soap, especially before and after eating and after using the toilet, should be promoted among all students and staff. Local health authorities should closely monitor acute gastroenteritis events, especially during and after floods. Routine food sanitation surveillance and hygiene training sessions for food handlers should be resumed immediately.

Conclusion

A food poisoning outbreak occurred in a secondary school with an attack rate of 40.4%. Rotavirus G3P[8] was the most likely pathogen responsible since it was detected in the majority of cases. The most affected group were students. No severe case or death was reported. No cluster of food poisoning or acute diarrhea was detected in the local community during the same period. Exposure to foods or drinks from the school canteen was a risk factor. While we were unable to detect rotavirus in the environment, our analytic and environmental results suggested contamination of the school water supply as the most likely source of the outbreak. The groundwater well located close to a cesspool and the lack of a water treatment system were two issues that need to be addressed. Our investigation demonstrated that contaminated drinking water is a key public health risk. To ensure the safety of the water supply, we recommended routine water quality testing and the installation of a groundwater treatment system.

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Suggested Citation

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Risk of Coronavirus Disease 2019 (COVID-19) in Special Military Operations in Southern Thailand, 2021

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Abstract

On 12 Oct 2021, the Department of Disease Control received a notification of a coronavirus disease 2019 (COVID-19) cluster in a military camp in Southern Thailand. In collaboration with local health authorities, we investigated the outbreak to describe case characteristics, identify risk factors, and provide control measures. We conducted a descriptive study by reviewing laboratory results and medical records and interviewing the cases and military staff. A retrospective cohort study was undertaken to determine the potential risk of COVID-19 by Poisson regression with robust standard errors. Of 188 military personnel, 37 were confirmed cases (attack rate 19.7%). The attack rates among males and females were 28.97% and 10.71%, respectively. Most cases (97.3%; 36/37) had mild symptoms and one was asymptomatic. Attending a special operation in communities or forest (adjusted risk ratio (RR) 2.75 [95% CI 1.60–4.75]) and engaging in high-risk behaviors (adjusted RR 3.41 [95% CI 1.64–7.06]) were risk factors, while completing 2-dose vaccination schedule had a tendency to prevent COVID-19 infection. We recommend the implementation of strict symptom monitoring measures among special operation forces, efforts to promote personal hygiene, and we encourage all military staff to undergo full vaccination.

Keywords: COVID-19, military camp, vaccine, Thailand

Introduction

On 11 Mar 2020, the World Health Organization (WHO) declared coronavirus disease 2019 (COVID-19) as a global pandemic. COVID-19 is caused by severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2).[1] By September 2021, the WHO reported 231 million COVID-19 cases and 4.7 million deaths worldwide.[2] As of 30 Sep 2021, Thailand had faced over 1 million cases and about 11,000 deaths.[3] Since April 2021, the southern region of Thailand has accounted for 116,000 cases, specifically in the four southernmost provinces: Yala, Narathiwat, Songkhla, and Pattani.[4]

COVID-19 outbreaks in military camps has been documented in many countries such as Canada, South Korea, and the United States. The European Union and the European Economic Area also reported 29 clusters of COVID-19 among their military personnel.[5] Factors contributing to the infection within these clusters include close proximity in the working environment, shared canteens, and social gathering during training sessions and meetings.[5]

On 12 Oct 2021, the joint investigation team of the Division of Epidemiology, Department of Disease Control (DDC), Ministry of Public Health, received a notification of a cluster of COVID-19 cases in a military camp in Narathiwat Province from the Office of Disease Prevention and Control Region 12 Songkhla (ODPC 12). The joint investigation team, comprising health personnel from various sources, including the Division of Epidemiology, ODPC 12, Narathiwat Provincial Public Health Office, Si Sakhon District Health Office and Si Sakhon Hospital, conducted an investigation during 12–15 Oct 2021. The aims of the investigation were to describe epidemiological characteristics of the cases, identify potential sources and risk factors, and provide recommendations and control measures.

Methods

The investigation comprised three parts as follows.

Descriptive Study

A descriptive study was conducted involving data collection, which consisted of reviewing laboratory records of confirmed cases, interviewing confirmed cases and military staff, and tracing contacts of confirmed cases using a semi-structured questionnaire. The study population included all people in the military camp between 15 Sep and 5 Nov 2021.

The definition of a patient under investigation was any person in the study population who came into contact with a COVID-19 case and developed at least one of the following symptoms: fever, cough, sore throat, nasal discharge, sputum, headache, myalgia, diarrhea, anosmia, ageusia, dyspnea, conjunctivitis and rash. A probable case was any person in the study population with positive SARS-CoV-2 by a commercial COVID-19 antigen test kit (ATK), approved by the Thai Food and Drug Administration. A confirmed case was a person in the study population who was diagnosed with positive SARS-CoV-2 by reverse transcription polymerase chain reaction (RT-PCR). The ATK sample collection was performed by a military nurse while nasopharyngeal swab for RT-PCR was performed by health personnel at Si Sakhon Hospital.

For contact tracing, a close contact was anyone who contacted with a COVID-19 case within a 2-meter distance for more than five minutes or who stayed in the same unventilated area with the case for more than 30 minutes within two days prior to symptoms onset or after developing symptoms. A high-risk close contact was a close contact who did not wear proper personal protective equipment. A low-risk close contact was a close contact who did not meet the criteria for being a high-risk contact.

Contact tracing was performed using an online semi-structured questionnaire adapted from the DDC standard questionnaire. We searched for additional military staff who were under investigation and high-risk contacts using the same questionnaire and combined these data with military nurse records.

Descriptive findings were presented as proportion and percentage for categorical data, while median and interquartile range (IQR) were presented for continuous data.

Environmental Study

We conducted a walk-through environmental survey of the military camp. The modalities in the camp such as dining areas and fitness center were observed. We also conducted in-depth interviews with the military nurses to gather information about the routine activities of camp staff. Accommodation features and quarantine protocols for new soldiers and for those returning from vacation or from a special operation were inspected. The special operation commander was interviewed for characteristics of the operations conducted outside the camp premises.

Analytic Study

We conducted a retrospective cohort study to identify possible risk factors of COVID-19 infection in the military camp. We defined a case as anyone presented in the military camp between 15 Sep and 5 Nov 2021 and tested positive for SARS-CoV-2 by ATK. All other personnel were defined as non-cases.

The outcome variable was the SARS-CoV-2 ATK result. Independent variables included gender, age, underlying disease, vaccine history, special operation attendance, and personal hygiene. We used Poisson regression with robust standard errors for both univariable and multivariable analyses. Variables with a p-value less than 0.1 in the univariable analysis and were also modifiable in practice were included in the initial multivariable analysis. Results were presented in the form of risk ratio (RR) and adjusted RR with 95% confidence interval (CI).

Ethic Consideration

This study was performed as part of the outbreak investigation following the Thai-DDC mission. We strictly protected the confidentiality of the participants and adhered to the ethical principles of the Declaration of Helsinki.

Results

Descriptive Study

The camp housed a total of 188 soldiers and was composed of three main sectors: commander sector, female sector, and operation sector. Based on the contact tracing, there were 103 high-risk and 84 low-risk close contacts. All high-risk contacts were tested by ATK, of which 36 were positive and all were later confirmed by RT-PCR. The high-risk contacts who presented negative ATK results were quarantined for 14 days and were re-tested on day 14 or when symptoms developed. Totally, there were 37 confirmed cases (including the index case) and no deaths. Thirty-six cases developed mild symptoms and one was asymptomatic. The distribution of symptoms is shown in Figure 1. The overall attack rate was 19.7%. The specific attack rate was highest in the operation sector 58.0% (29/50), followed by the female sector 10.7% (6/56), and the commander sector 2.4% (2/82).

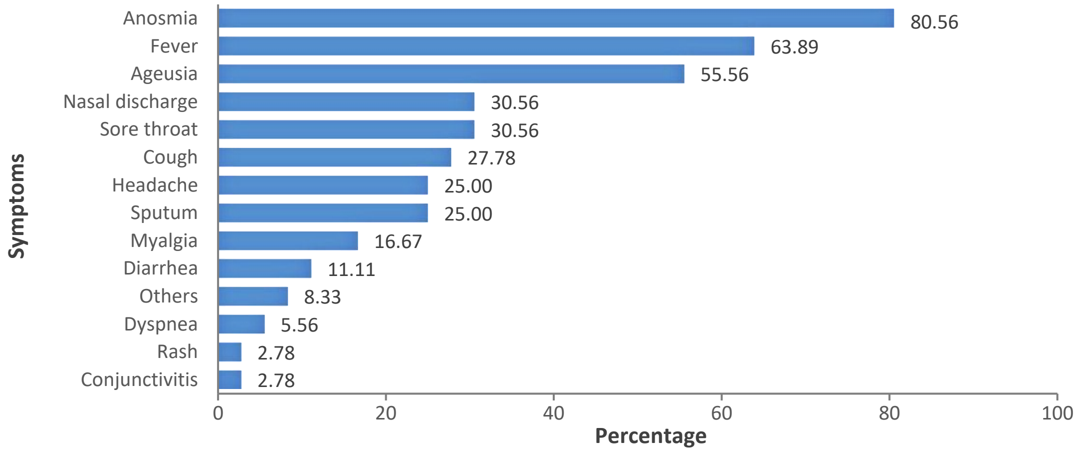

Figure 1. Frequency of symptoms among COVID-19 cases in a military camp in Southern Thailand, 15 Sep–5 Nov 2021 (n=36)

The median (IQR) age of the cases was 31 (29–36) years and the male-to-female ratio was 5:1. The median (IQR) cycle threshold value was 21.3 (19.6–25.2). Almost half (46.0%, 17/37) of the cases had underlying disease, the most common being allergic rhinitis (47.1%). About half (19/37) had received a two-dose vaccination. Seventeen had received one-dose, and there was only one unvaccinated case. The vaccine history and corresponding attack rates are shown in Table 1. The attack rates among males and females were 29.0% and 10.7%, respectively. The attack rates among attendees of a special operation was 51.5% and for those attending the camp fitness center was 50.0%.

Table 1. Vaccination history of confirmed cases in a military camp in Southern Thailand, 15 Sep–5 Nov 2021 (n=149)

Vaccination history	Attack rate by history of vaccination
At least two doses (at least 14 days)	
CoronaVac + CoronaVac / BBIBP-CorV + BBIBP-CorV	13.0% (6/46)
CoronaVac + ChAdOx1	21.4% (9/42)
ChAdOx1 + ChAdOx1	12.5% (4/32)
One dose	
ChAdOx1	60.7% (17/28)
No vaccination	100.0% (1/1)

CoronaVac is from Sinovac®, ChAdOx1 is from AstraZeneca®, BBIBP-CorV (Vero Cells) is from Sinopharm®.

The epidemic curve is presented in Figure 2. The index case developed symptoms on 29 Sep 2021 while the first case's symptoms started on 22 Sep 2021. The first case was a soldier returning from a special operation, which involved military duty in Bacho District.

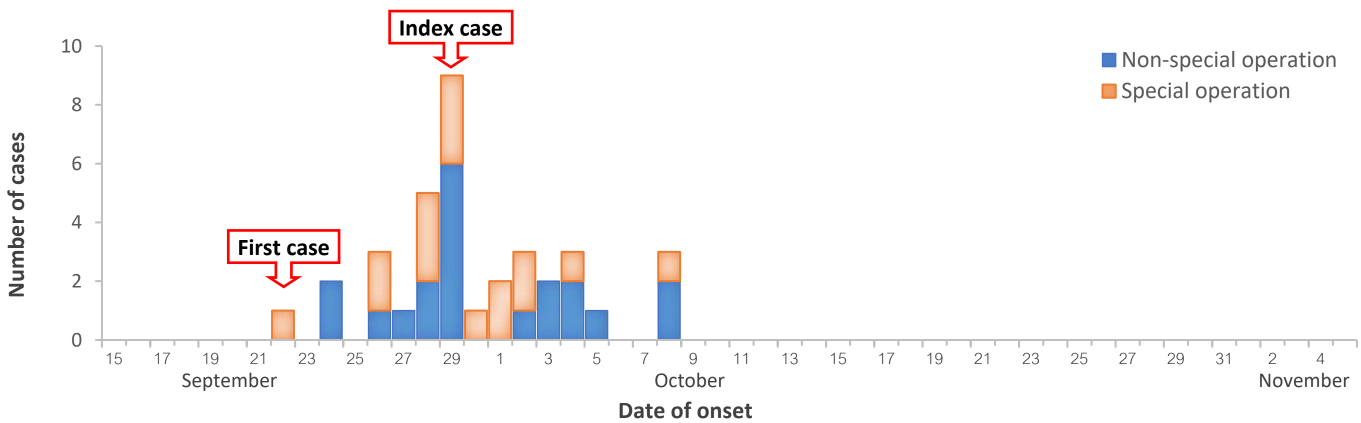

Figure 2. Epidemic curve of a COVID-19 cluster in a military camp in Southern Thailand, 15 Sep–5 Nov 2021 (only symptomatic cases, n=36)

Environmental Study

From the walk-through survey, we found that in the operation sector, 26 personnel shared one bedroom of dimension 60 m^2. All military staff shared one bathroom which was cleaned once a day. The camp had a fitness center and a canteen, which everybody in the camp could use; however, there was no specific regulations such as time limit or the number allowed to use at one time.

Analytic Study

We interviewed 163 soldiers out of 188 (response rate 87%). Being male (RR 2.70, 95% CI 1.20–6.10), having an underlying disease (RR 2.00, 95% CI 1.04–3.85), attending a special operation (RR 3.35, 95% CI 1.98–5.65), and using the camp fitness center (RR 2.63, 95% CI 1.51–4.59) were significantly associated with an increased risk of infection. Completing a two-dose vaccination schedule (RR 0.37, 95% CI 0.21–0.63) and good personal hygiene (RR 0.24, 95% CI 0.14–0.41) were significant protective factors (Table 2).

Table 2. Attack rates and risk ratios of COVID-19 infection in a military camp in Southern Thailand, 15 Sep–5 Nov 2021 (n=163)

Variables	Case	Non-case	Attack rate (%)	Risk ratio	95% CI	*P*-value
Gender						
Male	31	76	28.97	2.70	1.20–6.10	0.017
Female	6	50	10.71			
Age (years)						
≥35	11	46	19.30	0.79	0.42–1.48	0.455
<35	26	80	24.53			
Underlying disease$						
Yes	7	10	41.18	2.00	1.04–3.85	0.037
No	30	116	20.55			
Attending special operation#						
Yes	17	16	51.52	3.35	1.98–5.65	<0.001
No	20	110	15.38			
History of attending camp fitness*						
Yes	10	10	50.00	2.63	1.51–4.59	0.001
No	27	115	19.01			
Completing two-dose vaccination±						
Yes	19	102	15.70	0.37	0.21–0.63	<0.001
No	18	24	42.86			
Personal hygiene§						
Good	10	78	11.36	0.24	0.14–0.41	<0.001
Poor	27	48	36.00			
Sharing a bedroom						
Yes	29	76	27.62	2.00	0.98–4.10	0.057
No	8	50	13.79			
Sharing a bathroom						
Yes	35	108	24.48	2.45	0.63-9.44	0.194
No	2	18	10.00			

$Includes chronic lung diseases, cardiovascular diseases, diabetes mellitus, obesity, gastrointestinal diseases, orthopedic disorders, inflammatory arthritis diseases, and allergic rhinitis.

#Soldiers were tasked to go on outreach in the communities or in the forest to fight against insurgents.

**One of the participants did not respond to the question regarding their attendance at the fitness camp.*

±Full vaccination means completing two doses for at least 14 days since the last dose (reference = no vaccination plus single-dose vaccination).

§Good hygiene was defined as always wearing a face mask when in public and always or sometimes washing hands before and after touching public items while poor hygiene was defined as never or sometimes wearing a face mask or never washing hands.

On multivariable analysis, due to the small number of cases, we limited the number of variables to no more than four. We omitted sex and underlying disease as our intention was to focus on modifiable factors. We combined personal hygiene with accommodation sharing into a new variable, 'high-risk behavior'. In the final model, the adjusted RRs of attending a special operation and high-risk behaviors were 2.75 (95% CI 1.60–4.75), and 3.41 (95% CI 1.64–7.06), respectively. Receiving a two-dose vaccination showed a tendency towards protecting against COVID-19 infection (Table 3).

Table 3. Adjusted risk ratios of COVID-19 infection in a military camp in Southern Thailand, 15 Sep–5 Nov 2021 (n=163)

Variables	Adjusted risk ratio	95% CI
Attending a special operation	2.75	1.60–4.75
Completing 2-dose vaccination	0.56	0.31–1.00
High-risk behavior$	3.41	1.64–7.06

CI: confidence interval

$Combining poor personal hygiene, fitness center use, and bedroom sharing (1 if all variables were true, 0 otherwise)

Discussion

We confirm a COVID-19 outbreak in a military camp. Most cases were male and almost half had joined a special operation unit off-site. The overall attack rate in this study was relatively high (19.7%) compared to outbreaks in similar settings. For instance, a COVID-19 outbreak in a military unit in South Korea presented an attack rate of 1.3%. The low attack rate in South Korea might be explained by a difference in testing protocol and quarantine measures between South Korea and Thailand.[6]

The highest specific attack rate was found in the operation sector. This sector is responsible for observing and assessing various risk situations, and executing clandestine military operations in the community. Thus, they might face a greater risk of contracting COVID-19 from the community than staff in other sectors.

From the environmental survey, the population density in the special operation sector was about 2.30 m^2 per person. This level is lower than that recommended by the Department of Health, Ministry of Public Health of at least 4 m^2 per person, a level which is believed to mitigate the risk of COVID-19 infection.[7]

Attending the camp fitness center and sharing a bedroom indirectly indicates that soldiers did not adhere to the recommended physical distancing policies. This fact is consistent with the finding from the environmental survey demonstrating that the camp did not limit the number of people using the fitness center and the canteen. It is well known that in fitness centers, wearing a mask while exercising is impractical. Studies have highlighted the increased risk of infection in attending fitness centers.[8]

Being fully vaccinated was found tends to be a protective factor in this study. The WHO reported that the full vaccination of CoronaVac in Chile could protect against symptomatic COVID-19 infection by 67%.[9] Moreover, as suggested by various studies, good personal hygiene, especially mask-wearing and hand-washing, have been reported to have a protective effect.[10–12] A previous study in Thailand showed that wearing a mask during contact with a COVID-19 case and frequent hand washing can reduce the risk of COVID-19 infection by approximately 77% and 67%, respectively.[13]

Limitations

This study contained both strengths and weaknesses. One of the strengths was the use of primary data from interviewing confirmed cases, non-cases, and involved military staff. However, there are some limitations. First, nonparticipation and nonresponse can bias the results of a cohort study.[14] In this study the nonresponse rate was approximately 13%, most of whom were non-cases and were not part of the special operation unit, implying that our estimated risk ratio was likely to be underestimated. Second, ATKs were mainly used rather than RT-PCR due to the camp protocol. The false-negative property of ATK may have resulted in our attack rate to be underestimated. Lastly, the questionnaire asked for historical data of the participants. Thus, memory bias was inevitable.

Public Health Recommendations

We recommend that strict monitoring of symptoms among soldiers returning from special operations, with quarantining for symptomatic cases, be promptly implemented. This measure will help identify possible cases and entail timelier isolation of those cases to prevent further transmission. Personal protective behaviors against COVID-19, such as mask-wearing, hand-washing and physical distancing where possible, should be emphasized to all camp staff. Limiting the number of people using the camp fitness center is also recommended. The vaccination program in the camp should be expedited. Soldiers joining the special operations unit should be considered for vaccination priority as they tend to face a greater risk of infection than others.

Conclusion

This investigation documented the presence of a COVID-19 outbreak in a military camp with an overall attack rate of 19.7%. Almost all cases developed mild symptoms. Joining the special operation unit was a significant risk factor. Other risk factors included high-risk behaviors such as sharing an accommodation and/or infrequent use of face mask. Completing a two-dose vaccination schedule had a tendency to prevent COVID-19 infection. To prevent further outbreaks, strict monitoring of COVID-19 symptoms among the camp staff, especially soldiers returning from special operations outside the camp, should be promptly enforced.

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Staphylococcal Food Poisoning Outbreak from a Community Gathering, Wang Nuea District, Lampang Province, Northern Thailand, July 2022

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Abstract

On 17 Jul 2022, the Thailand Department of Disease Control was notified about a food poisoning cluster related to a local funeral. We investigated to identify epidemiological characteristics of the outbreak, determine sources, and provide recommendations. A descriptive study and a retrospective cohort analysis were performed. Suspected cases were funeral participants or their household members who had at least one of the following: nausea, vomiting, abdominal pain, diarrhea, or bloody mucous stool during 17–20 Jul 2022. We used multiple logistic regression and transformed the adjusted odds ratio (AOR) to the adjusted risk ratio (ARR). We interviewed chefs and inspected the kitchen. Clinical specimens and food samples were sent for bacteria culture. Three hundred eighteen cases were identified. Ten patients (3.1%) had a shock; three had a septic shock; none died. The median age was 58 (range 47–66). The pork in the lunch boxes (ARR 7.80, 95% CI 0.75–81.34) was the most likely source. Improper food storage and cross-contamination risk were recognized. This outbreak was due to *S. aureus* with enterotoxin genes A and C, which were isolated from patients, food, and food handlers. Safety standards should be monitored, particularly in large community gatherings where the elderly attend.

Keywords: food poisoning, outbreak investigation, Staphylococcus aureus, community-gathering, food-handlers

Introduction

Food poisoning is an illness resulting from consuming food contaminated with pathogenic bacteria, viruses, parasites, or chemical substances. Globally, foodborne hazards caused 600 million foodborne illnesses and 420,000 deaths in 2010 and bacteria are one of the most common causes of outbreaks.[1,2]

In Thailand, the morbidity rate of food poisoning from January to August 2022 was 58 per 100,000 population, and no fatal case was reported.[3] While in 2019 and 2020, the morbidity rates were 166 and 135 per 100,000 population, respectively, and only a single fatal case was reported each year. The reported pathogens from the surveillance of the food poisoning and acute diarrhea included *Clostridium perfringens*, *Staphylococcus aureus*, *Vibrio parahaemolyticus*, *Salmonella* spp., *Escherichia coli*, rotavirus, and norovirus.[4,5] *Staphylococcus aureus* is a gram-positive cocci bacterium which commonly colonizes in the human's anterior nares and may be shed onto healthy skin.[6] Given the right conditions of warmth, moisture, pH, and time, some strains multiply and secrete enterotoxins which are heat-stable proteins[7]. Following the ingestion of staphylococcal enterotoxins, a person may develop staphylococcal food poisoning. The symptoms include nausea, vomiting, abdominal cramps, watery diarrhea, and, seldomly, fever. Incubation period and severity vary depending on the amount of toxins ingested and health condition of a person.[8] Usually, the incubation period is 30 minutes to 8 hours with recovery period varying within 12–48 hours.[8–10] Patients usually only need supportive and symptomatic treatments; however, appropriate fluid replacement should be ensured as severe dehydration may occur in infants, people with underlying illness, and the elderly.[8,9]

On 17 Jul 2022 around 20:00, the National Department of Disease Control was unofficially notified about a food poisoning cluster. All cases were related to a cremation ceremony at the funeral which was held at Rong Kor Subdistrict, Wang Nuea District, Lampang Province. There were approximately four hundred participants who mostly resided in Lampang Province, with a few coming from nearby provinces of Phayao and Chiang Rai. The lunch boxes were served from 10:30 to 11:00 on the same day. Around noon, groups of funeral participants visited Wang Nuea Hospital with gastrointestinal symptoms. As the number of patients exceeded the capability of the facility, some patients were transferred to other nearby district hospitals. The joint investigation team, comprising members of the Thailand Department of Disease Control and local health staff, launched a field investigation during 18–20 Jul 2022. The investigation objectives were to identify epidemiological characteristics of the outbreak, determine the sources of the outbreak and risk factors, and recommend appropriate preventive and control measures.

Methods

Setting

Wang Nuea District is the northernmost district of Lampang Province, Northern Thailand, connected to Phayao and Chiang Rai provinces. It has a 30-bed district hospital and ten sub-district health promoting hospitals (i.e., health centers) for eight subdistricts. Rong Kor Subdistrict, where the funeral was held, had a population of 10,908 and 17 villages. Approximately 28% of the residents were over 60 years of age. The funeral was arranged for an important community figure. Thus, a large number of the residents joined the event, though the exact number of the participants was unknown. On the last day of the funeral (17 July), the cremation ceremony was held at Village 3 of Rong Kor Subdistrict which included monk chanting session in the morning and cremation in the afternoon. The family members of the deceased were expected to prepare refreshment and lunch for every participant.

Descriptive Study

We interviewed epidemiologists, healthcare workers, and patients at Wang Nuea Hospital. We reviewed medical records and the number of cases from related ICD-10 codes (Table 1) in Wang Nuea Hospital and ten health centers in the district.

Table 1. ICD-10 codes used for active case finding in food poisoning outbreak in Wang Nuea District, Lampang Province, Thailand, 17–18 Jul 2022

ICD-10 Code	Diagnosis	Total number reviewed	Number of food poisoning cases (%)
A04.8	Other specified bacterial intestinal infections	0	0
A04.9	Bacterial intestinal infection, unspecified	115	115 (100.0%)
A49.9	Bacterial infection, unspecified	5	5 (100.0%)
A05.8	Other specified bacterial foodborne intoxications	1	1 (100.0%)
A05.9	Bacterial foodborne intoxication, unspecified	27	27 (100.0%)
A08.3	Other viral enteritis	0	0
A08.4	Viral intestinal infection, unspecified	0	0
A08.5	Other specified intestinal infections	0	0
A09.0	Other and unspecified gastroenteritis and colitis of infectious origin	110	109 (99.1%)
A09.9	Gastroenteritis and colitis of unspecified origin	10	10 (100.0%)
R10.4	Other and unspecified abdominal pain	0	0
R11	Nausea and vomiting	0	0
	Total	**268**	**267 (99.6%)**

Suspected cases were funeral participants or their household members who had at least one of these symptoms: nausea, vomiting, abdominal pain, diarrhea, or mucous bloody stool during 17–20 Jul 2022. Confirmed cases were suspected cases with rectal swabs testing positive for the bacterial or viral pathogen.

Active case finding was conducted at all public health facilities in Wang Nuea District, and three hospitals in the nearby districts (two in Lampang Province and one in Chiang Rai Province). We contacted health officers at each hospital to retrieve lists of patients from relevant ICD-10 codes through the hospital information system and lists of patients who had complaints of symptoms as in the suspected case definition from the hospital registry during 17-20 Jul 2022. Then, we reviewed each medical record and interviewed the patients using a questionnaire via phone if the subjects were already discharged. The questionnaire included demographic data, onset and symptoms, funeral participation, and food consumption listed from the funeral.

Active case finding in the communities was done in Village 3 where the funeral was held and Villages 9 and 16, the nearby villages (Figure 1) as these areas were the residences of the majority of the funeral participants. We announced via the village loudspeakers asking anyone who had symptoms compatible with the definition of the suspected case to visit the nearby health promoting hospital. There, health personnel interviewed the villagers, collected rectal swabs in those who still had diarrhea, and provided supportive treatment.

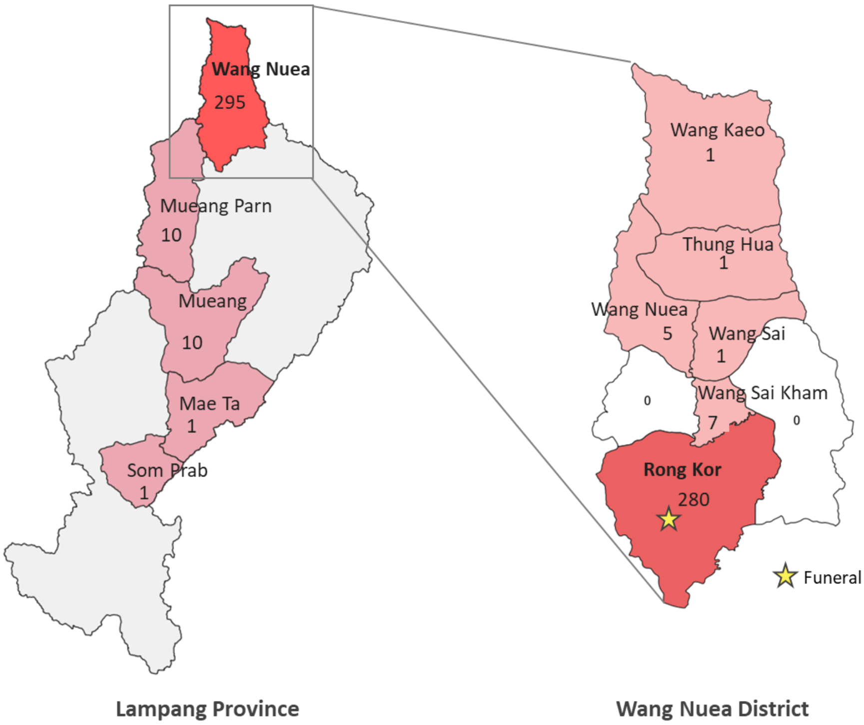

Figure 1. Distribution of food poisoning cases in Lampang Province and Wang Nuea District, Thailand, 17–18 Jul 2022 (n=308)

We presented the demographic characteristics, food consumption items from the funeral, and clinical features using median with the interquartile range for continuous data and frequency and percentages for categorical data. We used Microsoft Excel and Stata 16.0 to analyze the data.

Analytic Study

A retrospective cohort study was conducted to determine association of potential risk factors and being a case. The participants were patients who lived in Villages 3, 9, 16, and their family members. We used a single-stage cluster sampling approach with households as the primary sampling unit and individuals as the elementary sampling unit. The sample size required to estimate the odds ratio with 95% confidence and relative precision of 70% was approximately 30 for the unexposed groups. Adding the exposed group in a 1:1 ratio, the cohort needed at least 60 persons (Appendix 1). Given the design effect of 2.5 and the non-response rate of 0.1, the study needed around 170 persons. Based on the civil registry of Villages 3, 9, and 16, the average number of people per house was 2.58 persons. The number of sampled households in each village was calculated to represent the distribution of household that had at least one case in that village. From 144 household of cases (100, 27, 17 houses in Villages 3, 9, 16, respectively), we recruited 85 households (59, 16, 10 houses in Villages 3, 9, 16, respectively). We sorted house numbers of each village from the smallest to largest, then used circular systematic sampling to select the houses. Then we asked the index member for the phone numbers of everybody in their house to interview them directly. If the call could not be reached twice, we would ask another member about the history of funeral participation, food consumption, and symptoms.

The independent variables were gender, age, underlying disease, and food items from the funeral.

The dependent variable was being a case. In the univariable analysis, we calculated risk ratio (RR) with 95% confidence interval (CI). We selected variables with a p-value less than 0.1 for the multivariable analysis. We used logistic regression to estimate the adjusted odds ratio (AOR). Due to high disease incidence in this particular event and to conform with the crude RR in the univariable analysis, we transformed it into adjusted risk ratio (ARR) using the "adjrr" package in Stata for better interpretation.[11] We also performed additional analysis by adjusting for clustering effect on the ARR in order to check the robustness and the consistency of the results using the "svy" function in Stata.[12,13] Dose-response analysis was calculated in the form of risk ratio with 95% CI on significant variables.

Environmental Study

We interviewed the funeral host about the food items served and the source of each one. We conducted a walk-through survey of the kitchen and drinking water plants to observe the process and sanitation. We screened for coliform bacteria on kitchenware and drinking water in the kitchen using test kits. The chefs were interviewed about their current illnesses, the source of each food item, and the food preparation, cooking, and serving procedure. For the drinking water plants, we interviewed the pharmacists on the board of consumer protection, the owners, and the managers about the process and quality control.

Laboratory Study

We collected rectal swabs and vomitus from the suspected cases who still had diarrhea or vomiting and from every food handler on 18 Jul 2022. The rectal swabs were stored in tubes with Cary Blair medium and viral transport media, and vomitus was stored in plastic bags. Blood samples of the admitted cases whom the physician suspected sepsis were sent for hemoculture. On the same day, surface swabs from the kitchen and two lunch boxes were collected. One lunch box was sent out as a sample and each food component of the other lunch box was sent out as six separate samples. During the survey at the water plants, we collected bottler's hand swab, bottle swab, and water sample. Water samples were collected in new plastic bottles on 20 Jul 2022. All rectal swab specimens were sent for bacterial culture at the National Institute of Health laboratory, and we also randomly sent seven rectal swab specimens for viral polymerase chain reaction (PCR) testing. All specimens placed in foam boxes with ice packs were transported to the laboratory via buses, which took around 1–2 days. The temperature inside the boxes was cool but not measured.

Ethical Approval

This investigation was part of an emergency public health response. Verbal informed consent was requested before the interview and specimen collection. Only designated members of the investigation team could access the data files.

Results

Overview of Food Poisoning Situation in Wang Nuea District

By extracting food poisoning-related ICD-10 codes, we found the number of cases visiting hospitals in Wang Nuea District rose from 1–3 cases per day from 14–16 Jul 2022, to 250 cases on 17 Jul 2022. The epidemiologists and health care workers also reported incoming groups of patients having gastrointestinal symptoms starting around noon of 17 July.

Descriptive Study

This cremation ceremony was opened to all people in the community. The host ordered about 500 ice cream cups, 700 lunch boxes and water bottles. On 08:00, approximately 30 people who prepared the ceremony ate bok choy soup and steamed pork together. Ice cream cups and lunch sets, composed of Kao Moo Dang lunch box and a water bottle, were distributed to the participants at 10:00 and 10:30–11:00, respectively. Some participants (with unknown figure) took the extra lunch boxes back home.

From the active case finding, we found 318 cases (308 suspected and 10 confirmed cases). The male-to-female ratio was 1:1 and the median age was 58 years (range 47–66). Approximately 96.3% (308/318) lived in Lampang Province, others were from Chiang Mai, Payao, Nan, and Chiang Rai Provinces. About 88.1% (280/318) resided in the Rong Kor Subdistrict, particularly in Villages 3, 9, and 16 (Figure 1). Half of the patients (50.5%) were agriculturists.

Approximately 84.1% of cases attended the funeral. All cases ate the Kao Moo Dang lunch box, a Thai dish of marinated pork, steamed rice, boiled egg, sweet gravy, cucumber, coriander and black soy sauce. Approximately 74.7% of cases drank water from the packed bottle distributed at the funeral, 61.8% ate ice cream, 5.6% ate bok choy soup, and 4.9% ate steamed pork.

The epidemic curve (Figure 2) showed that the first case was a chef who had packed the lunch boxes but did not attend the funeral. She started developing symptoms at 10:00 on 17 Jul 2022. The number of cases increased from 10:00 and peaked at 13:00. The median and mean incubation period was 2.3 hours (range 1.5–3.0) and 3 hours (range 20 minutes–7.5 hours), respectively.

The most common symptoms were vomiting (88.2%), diarrhea (81.3%), and abdominal pain (80.7%). Half of the patients had nausea (53.5%), whereas only one-tenth had fever (9.9%). Most of the cases received hospital care (75% as outpatient and 14% as inpatient). Approximately 12.9% of patients received antibiotics. Ten patients (3.5%) had shock and three had septic shock; however, no deaths were reported. About one-third (35.2%) of patients had chronic medical conditions such as hypertension and diabetes.

Three males who had septic shock were 55–74 years old and two of them had chronic medical conditions (diabetes mellitus, hypertension, and dyslipidemia). After consuming the pork and rice in the lunch box for 1–2 hours, they started having nausea, vomiting 5–20 times, diarrhea 5–15 times, abdominal cramp, and syncope. They visited the hospital within a day after the onset. The initial systolic blood pressure was 58–83 mmHg and diastolic blood pressure was 40–58. No skin lesion was noted. The white blood cell was 13,060–18,740/µL, in which neutrophil was accounted to 79–88%. Two of them had acute kidney injury. White blood cell was also found in the stool. They received intravenous hydration, antibiotics, and norepinephrine, then they were discharged with complete recovery within 6 days.

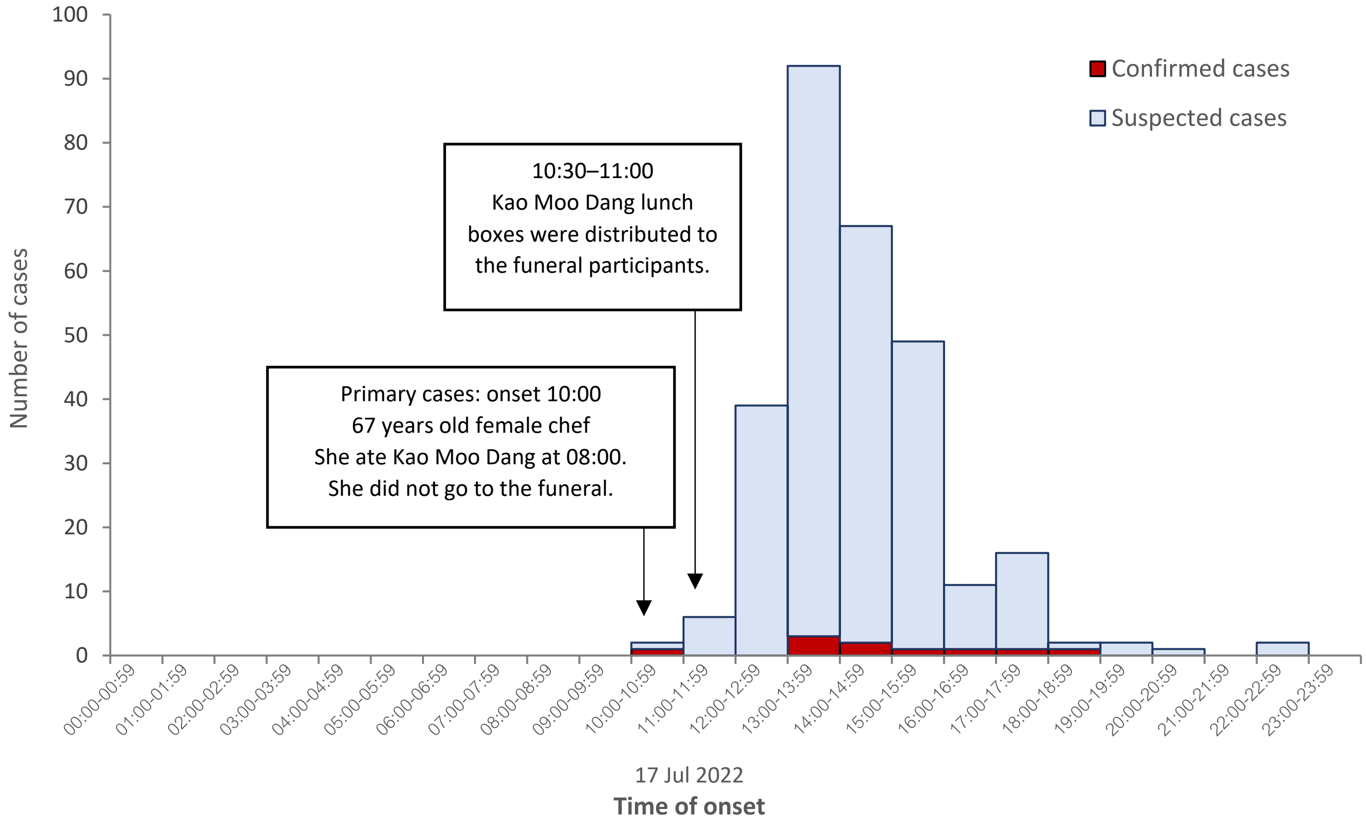

Figure 2. Epidemic curve of food poisoning cases in Wang Nuea District, Lampang Province, Thailand, 17–18 Jul 2022 (n=289)

Analytic Study

A total of 85 households or 228 persons were recruited to participate in the study from Villages 3, 9 and 16. The number of funeral participants and their family members were 139 (108 cases and 31 non-cases) and 89 (24 cases and 65 non-cases) persons, respectively.

From univariable analysis, the potential risk factors with a *p*-value less than 0.1 were pork, rice, steamed egg, cucumber, gravy, dipping sauce, ice-cream, drinking water, and steamed pork (Table 2). From the multivariable analysis with adjustment for clustering effect, only the pork had a *p*-value of less than 0.05 with the AOR of 90.94 (95% CI 3.42–2,420.46, *p*-value 0.008) and ARR of 7.80 (95% CI 0.75–81.34, *p*-value 0.0861). The actual design effect to account for the pork item for all households combined was 1.23. Table 3 presented dose-response relationship between the illness and amount of pork consumption, 2–3 tablespoons, half, and all pork in a lunch box. We found that the RR increased with the consumed amount increased, however the increasing trend was not statistically significant.

Table 2. Univariable and multivariable analysis of risk factors in food poisoning outbreak in Wang Nuea District, Lampang Province, Thailand, 17–18 Jul 2022

Factors	% Attack rate (case/total)		Crude RR (95% CI)	Adjusted OR with clustering effect (95% CI)	Adjusted RR with clustering effect (95% CI)
	Exposed	Non-exposed			
Male	58.68 (71/121)	57.01 (61/107)	1.03 (0.82–1.29)	-	-
Age ≥60	59.60 (59/99)	56.59 (73/129)	1.05 (0.84–1.31)	-	-
Underlying disease	64.93 (50/77)	54.30 (82/151)	1.20 (0.96–1.49)	-	-
Pork	89.04 (130/146)	2.44 (2/82)	39.51 (9.28–143.68)[a]	90.94 (3.42–2,420.46)	7.80 (0.75–81.34)
Rice	88.43 (130/147)	2.47 (2/81)	35.82 (9.10–140.94)[a]	10.94 (0.35–343.40)	1.96 (0.37–10.31)
Steamed egg	87.69 (114/130)	18.37 (18/98)	4.77 (3.13–7.28)[a]	1.09 (0.29–4.15)	1.01 (0.87–1.18)
Cucumber	90.91(90/99)	32.56 (42/129)	2.79 (2.16–3.61)[a]	2.06 (0.61–6.92)	1.09 (0.92–1.30)
Gravy	88.80 (111/125)	20.39 (21/103)	4.36 (2.96–6.41)[a]	0.34 (0.32–3.64)	0.91 (0.79–1.06)
Dipping sauce	88.79 (95/107)	30.58 (37/84)	2.90 (2.20–3.83)[a]	1.06 (0.25–4.46)	1.01 (0.86–1.18)
Ice-cream	86.73 (85/98)	36.15 (47/130)	2.40 (1.88–3.05)[a]	1.59 (0.61–4.15)	1.05 (0.94–1.18)
Water bottle	84.03 (100/119)	29.36 (32/109)	2.86 (2.12–3.87)[a]	1.21 (0.44–3.34)	1.02 (0.91–1.15)
Steamed pork	90.00 (9/10)	56.42 (123/218)	1.60 (1.26–2.02)[a]	35.52 (0.91–1,390.35)	1.27 (0.95–1.70)
Bok choy soup	83.33 (10/12)	56.48 (122/216)	1.48 (1.12–1.95)	-	-

RR: risk ratio, OR: odds ratio

[a]p-value <0.1

Table 3. Dose response analysis of pork in food poisoning outbreak in Wang Nuea District, Lampang Province, Thailand, 17–18 Jul 2022

Amount of pork consumption	% Attack rate (case/total)	Crude RR (95% CI)
2-3 tablespoons	85.71 (18/21)	35.14 (8.84–139.69)
Half	86.84 (33/38)	35.61 (9.01–140.75)
All	90.80 (79/87)	37.23 (9.46–146.59)

RR: risk ratio, CI: confidence interval

Chi^2 = 0.7, p-value = 0.706

Environmental Study

The cooking location was a half-cement, half-timber, 2-story detached house with a storefront for selling items and a large kitchen area at the back of the house. The kitchen was open and well-ventilated. It has a cement floor and a table for cooking in the middle. The shelf for storing was within 60 centimeters above the floor. The caterer team, composed of 6 persons, was experienced in making approximately 200–300 boxes lunch boxes for banquets/group gatherings.

The chefs purchased raw ingredients for the lunch boxes from various sources. Fresh pork packed in plastic bags were bought, transferred on a pickup truck from a shop in Phayao on 15 Jul 2022 at around 18:00–20:00, and stored in an ice cooler with crushed ice roughly 10 centimeters high for cooking on the following day. The other ingredients were purchased from shops and markets in the district to use only for this cooking session.

The cooking process started in the early morning on 16 Jul 2022. The chefs did not wear masks or gloves when preparing the food. At 06:00, the pork was taken out of the ice cooler, washed, cut, put in the bags, and placed in the same ice cooler. Then, at 13:00, the pork was marinated in the pot. From 19:00–24:00, other ingredients were prepared including cooking the rice using six normal-sized rice cookers. The rice was then scooped out and set aside in a large pot. Then, seven hundred eggs were steamed. The marinated pork was then brought out and heated until boiling. Once finished, the pork was put in a pot on top of the ice cooler as they thought this would be cold enough. The gravy and dipping sauce were then prepared. The cucumbers were peeled, sliced, and put on a tray, and the coriander was prepared. On 17 Jul 2022, from 03:00–08:00, all chunks of pork were chopped into thin pieces. The same cutting boards and similar knives were used for raw and cooked items. Then, the food items were distributed into 700 lunch boxes. The chefs used bare hands to pick a handful of chopped pork, one whole unpeeled steamed egg, a few pieces of coriander and cucumbers, a small bag of gravy, and a small bag of dipping sauce into each lunch box. Then all lunch boxes were packed into bags (10 boxes per bag) and delivered to the funeral at about 09:00 (Figure 3 and 4).

Figure 3. Pictures of Kao Moo Dang lunch boxes and transportation, Wang Nuea District, Lampang Province, Thailand, 17 Jul 2022

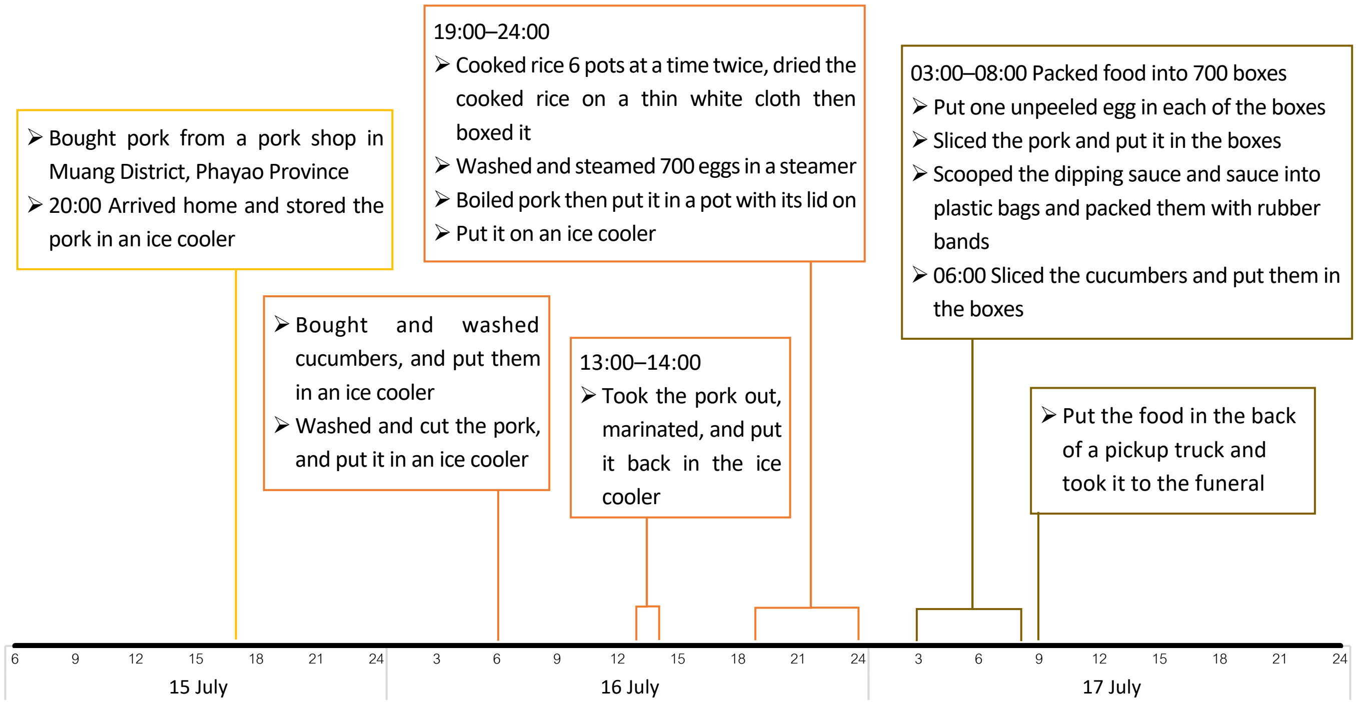

Figure 4. Timeline of the process of cooking Kao Moo Dang in food poisoning outbreak in Wang Nuea District, Lampang Province, Thailand, 17–18 Jul 2022

The chefs used cooking water ordered from three companies. The coliform bacteria screening was positive in the water from two agencies, A and B, and negative in water from agency C. For Drinking Water Plant A, the water had not been officially tested for hygienic standards in 2021. The staff reused the bottle caps after cleaning. For Drinking Water Plant B, the factory license could not be found on the day of the visit. The water had never been officially tested. There was no qualified quality control staff. Lastly, the practice of closing the bottle caps with bare hands was done in both plants.

Laboratory Study

Samples from the patients, food at the funeral, food handlers, kitchens, and drinking water plants were also sent for bacterial culture testing (Tables 4-6). *S. aureus* was found in all sample types: patient's rectal swab (6/20=30%), Kao Moo Dang (1/1=100% for the whole box, and also in its components, namely pork, cucumber, and steamed egg), food handler's rectal (1/6=16.7%) and hand swabs (3/5=60%). One S. aureus positive sample from each sample type was sent for susceptibility test and multiplex PCR. All four samples reported Methicillin-susceptible *S. aureus* (MSSA) with the detection of Staphylococcal enterotoxin genes A and C. Of seven rectal swab samples sent for viral PCR testing, one was positive for norovirus. *Samonella* spp. was also reported from rectal swabs of three patients and a food handler. The second most common organism identified from rectal swabs of the patients were *Salmonella* spp. and *Aeromonas* spp. (3/20=15% each). Several samples from surface swabs in the kitchen and water samples from the water plants were also found positive for Bacillus cereus group and Aeromonas species (detection rate equating 50–100% each).

Table 4. Results of the bacterial culture of samples from patients and food at the funeral in food poisoning outbreak in Wang Nuea District, Lampang Province, Thailand, 17–18 Jul 2022

Sample type	Number of samples sent for testing	Result	Number of samples with the bacteria (% positive)
Patients			
Rectal swab	20	*S. aureus*[1]	6 (30.0%)
		Salmonella spp.[2]	3 (15.0%)
		Aeromonas spp.	3 (15.0%)
		Aeromonas veronii biovarsobria	2 (10.0%)
		Plesiomonas shigelloides	2 (10.0%)
Vomitus	1	*Aeromonas* spp.	1 (100.0%)
Blood*	5	*Staphylococcus hominis*	1 (20.0%)
Food at the funeral			
Kao Moo Dang (whole box)	1	*S. aureus*[1]	1 (100.0%)
		E. coli[3]	1 (100.0%)
Kao Moo Dang components			
- Rice	1	*E. coli*	1 (100.0%)
- Pork	1	*S. aureus*	1 (100.0%)
		Aeromonas spp.	1 (100.0%)
- Cucumber	1	*S. aureus*	1 (100.0%)
		Aeromonas spp.	1 (100.0%)
- Steamed egg	1	*S. aureus*	1 (100.0%)
		B. cereus	1 (100.0%)
- Gravy	1	*Aeromonas* spp.	1 (100.0%)
		B. cereus group	1 (100.0%)
- Black source	1	-	0
Ice cream	1	*Vibrio* spp.	1 (100.0%)
Drinking water in closed bottle	1	*Aeromonas caviae*	1 (100.0%)

**Taken while being admitted in the hospital by attending physician.*

[1] One sample was sent for the Kirby-Bauer disk diffusion susceptibility test and multiplex PCR and reported Methicillin-susceptible S. aureus (MSSA) with the detection of Staphylococcal enterotoxin genes A and C.

[2] One sample was sent for serotyping and reported Salmonella serovar Rissen.

[3] One sample was sent for multiplex PCR and cell adherence assay and reported E. coli non O157:H7, non-enteroaggregative E.

Table 5. Results of the bacterial culture of samples from food handlers and kitchen in food poisoning outbreak in Wang Nuea District, Lampang Province, Thailand, 17–18 Jul 2022

Sample type	Number of samples sent for testing	Result	Number of samples with the bacteria (% positive)
Food handlers			
Rectal swab	6	*S. aureus*[1]	1 (16.7%)
		Salmonella spp.[2]	1 (16.7%)
Hand swab	5	*S. aureus*[1]	3 (60.0%)
		B. cereus group	3 (60.0%)
Kitchen			
Surface swab			
- Ice cooler	1	*Aeromonas* spp.	1 (100.0%)
		Aeromonas hydrophila	1 (100.0%)
- Pot for boiling pork	1	-	
- Random kitchenware	2	*B. cereus*	1 (100.0%)
- Chopping board	1	-	0
- Knives	1	-	0
- Water bottle pump	1	-	
Drinking water gallon (Plant A)	1	*B. cereus* group	1 (100.0%)
Drinking water gallon (Plant B)	1	*B. cereus*	1 (100.0%)

[1] One sample was sent for the Kirby-Bauer disk diffusion susceptibility test and multiplex PCR and reported Methicillin-susceptible S. aureus (MSSA) with the detection of Staphylococcal enterotoxin genes A and C.

[2] One sample was sent for serotyping and reported Salmonella serovar Rissen.

Table 6: Results of the bacterial culture of specimens from drinking water companies in food poisoning outbreak in Wang Nuea District, Lampang Province, Thailand, 17–18 Jul 2022

Sample type	Number of samples sent for testing	Result	Number of samples with the bacteria (% positive)
Drinking Water Plant A			
Bottler's hand swab	1	*Aeromonas hydrophila*	1 (100%)
		Aeromonas caviae	1 (100%)
Untreated water	1	*B. cereus*	1 (100%)
Cup-filled drinking water	1	*Aeromonas* spp.	1 (100%)
Bottle-filled drinking water	1	-	0
Inside surface of a bottle cap	1	-	0
Inside surface of a bottle	1	*Aeromonas hydrophila*	1 (100%)
Drinking Water Plant B			
Bottler's hand swab	2	*Aeromonas caviae*	2 (100%)
		Aeromonas hydrophila	2 (100%)
		Aeromonas spp.	1 (50.00%)
Untreated water	1	*Aeromonas* spp.	1 (100%)
		B. cereus group	1 (100%)
Bottle-filled drinking water	1	-	0
Inside of a bottle	1	*Aeromonas caviae*	1 (100%)
		Aeromonas spp.	1 (100%)
		B. cereus group	1 (100%)

**Bottlers are the water plant staff who are responsible for filling the water in the drinking bottles and closing the caps.*

Actions Taken

During our investigation, we advised people to discard the lunch boxes and the food handlers who hold the food catering, to boil utensils for at least 3 minutes as this could inactivate the enterotoxins and clean the food preparing surfaces using diluted sodium hypochlorite solution to obtain a concentration of 1 g/L.[8,21] The hospital epidemiology team had temporarily conducted an ad-hoc food poisoning surveillance and prevention in the communities until the outbreak subsided. The Wang Nuea and Wiang Pa Pao local board of consumer protection visited the drinking water companies and examined the factory hygiene against the standards.

Discussion

As cases exhibited only gastrointestinal symptoms, predominantly vomiting, as early as 30 minutes after consuming the food in the lunch box. Enterotoxin of *S. aureus* and toxin of *B. cereus* were considered as possible etiologic agents. The laboratory study showed that *S. aureus* with enterotoxin genes A and C was the main pathogen isolated from the patients, food, and food handlers. Although the other pathogens identified, including *Salmonella* spp., *Aeromonas* spp., *Plesiomonas shigelloides*, and norovirus may cause similar gastrointestinal symptoms, they usually have a longer incubation period and less prominent vomiting Therefore, the most likely pathogen causing this outbreak was S. aureus whereas the identification of other organisms were likely due to concurrent contamination.[9,10]

Despite the outbreak occurring among the elderly, this event had lower hospitalization rate (14%) compared to previous staphylococcal food poisoning outbreaks where approximately 33.3–82.4% of the cases were hospitalized. Most of the cases in those studies were infants, elders, pregnant women, and handicapped persons, and they were mostly discharged within 1–2 days.[12–14] This might be because the district hospitals had limited bed and would only admit those with hypotension or persistent symptoms. Other than this, the patients were given intravenous fluid or medication as a supportive treatment at the emergency department and discharged after the clinical condition was stable. In addition, hypotension due to dehydration was known, however, septic shock was rarely reported.[8,9,12–17] Though the septic-shock cases in this event did not have confirmed bacteria culture from clinical specimens, considering the exposure, the early onset, and the symptoms, they still concurred with staphylococcal food poisoning. A study reviewed that enterotoxins could stimulate T lymphocyte activity which led to cytokine release and systemic shock.[8] Therefore, the cause of the septic-shock cases was likely to be the same pathogen as other cases.

The epidemic curve showed a point common source pattern with the likely onset around the same time when the food was distributed at the funeral. Most cases lived in the same subdistrict as where the funeral was held. Moreover, the cases were not only limited to the funeral participants, but also their family members. Laboratory results from this menu also showed the same suspected pathogen as found in the patients. Therefore, the Kao Moo Dang lunch box distributed at the funeral was the most likely source.

The pork In Kao Moo Dang was suspected to be the main source of *S. aureus*, either by the conventional multivariable logistic regression or by the multivariable logistic regression after adjusting for clustering effect. *S. aureus* in food poisoning outbreaks is often found in unrefrigerated or improperly refrigerated meat.[10] In this outbreak, raw pork was not stored at the optimal temperature for approximately a day before being cooked. This might have allowed the bacteria to multiply and produce the toxin. By storing raw meat at temperatures below 5 degrees Celsius and cooking meat or reheating it at a temperature of ≥72 degrees Celsius (duration depends on the temperature and food amount), the proliferation of bacteria and enterotoxin could be limited.[7,8,18]

S. aureus from pork might contaminate other food items. Though heat can kill *S. aureus*, the heat-stable toxin could remain through the subsequent cooking process. *S. aureus* might again contaminate the pork after being cooked since the cooks used the same cutting blocks, similar knives for raw and cooked meat, and the same ice cooler to store the raw meat. Each food item was then placed in the lunch boxes with bare hands. This process could cause contamination of bacteria and toxins with other food items. Although we could not identify how *S. aureus* primarily contaminated the pork, the contamination could have been mitigated by wearing face mask, using separated storage containers and utensils between raw and cooked food, and using separated ladle or wearing gloves when distributed each cooked food.[18]

For this event, *Aeromonas* spp. was considered an opportunistic pathogen that could cause diarrhea through the ingestion of contaminated water or foods. The genus Aeromonas originates from an aquatic environment. Typical habitats for these bacteria are freshwater.[9] Bacillus cereus group also has natural habitat in aquatic environments. Some strains are known to cause food poisoning outbreaks around the world.[19] In this outbreak, groundwater, reused bottles, and the hands of workers were found contaminated with Aeromonas species and *Bacillus cereus* group, but not in the water in packed bottles; however, in the kitchen, the *Bacillus cereus* group was found in water gallons from these two companies. Though this could be an accidental contamination of the water from the companies, the water treating standards should be monitored as both companies had not undertaken hygienic evaluation by responsible authorities for years. Since bacterial contamination could not be ruled out, always boiling water before consuming should be considered.[20]

Limitations

The identification of households based on known cases to be selected in the study cohort might have caused selection bias. Additionally, underestimation of the relative risk might have occurred given that family members of the patients might have been exposed to other risks (such as direct contact with the patients) apart from consuming the suspected food. Information bias might have occurred as exposure history of some family members was given by other family members and could have been inaccurate. Moreover, the list of cases from the hospital was given before the interviews, thus the interviewers could have been more determined to collect a more detailed history of the exposure. Furthermore, the cases might have not remembered the details clearly enough or amplified their recollections.

Public Health Recommendations

Strengthening food sanitation throughout the food chain is crucial. When transporting raw meat for more than 30 minutes, it is advisable to use ice coolers with sufficient ice. An appliance thermometer can be used to monitor storage temperature, aiming to keep it below 5 degrees Celsius. If a refrigerator is unavailable in the kitchen, storing meat for a maximum of 1-2 days with optimal temperature can be applied. To prevent contamination and cross-contamination, it is recommended to wear gloves and face masks, as well as to use separate kitchenware for the preparation and storage of raw and cooked food. Furthermore, reheating the food before distribution is advised. The health centers may consider engaging with the Village Health Volunteers to monitor large gatherings where food would be distributed to ensure food safety prior to the event. The Occupational and Environmental Health Unit of the District Health Office and Wang

Nuea Hospital could strengthen food sanitation surveillance, provide recommendations on food sanitation practices to local food handlers, and strictly monitor the standards of local kitchens. The district consumer protection board could continuously monitor the standards of local drinking water companies. As bacterial contamination along the process of bottling till consuming could not be excluded, people should be advised to boil drinking water from the local companies before consumption.

Conclusions

This event was a staphylococcal food poisoning outbreak that occurred among funeral participants and their household members in Wang Nuea District, Lampang Province. The pork in the Kao Moo Dang lunch boxes distributed at the funeral was the most likely source of contamination. Improper handling of food items and long preparation times could attribute to bacterial growth and cross-contamination, The local drinking water companies might pose a threat for future outbreak as they did not receive a recent hygienic evaluation. Local health authorities should enforce proper food sanitation practices and regularly monitor local food cateres.

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Identifying the Blood Lead Reference Value Based on the Advisory Committee on Childhood Lead Poisoning Prevention Guidelines and Factors Associated with Elevated Blood Lead Levels among Preschool Children in Thailand, 2019

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Abstract

The blood lead reference value (BLRV) is used for guiding lead prevention and control measures. It is usually defined as the 97.5th percentile of the population-based blood lead level in each country. This study aims to determine the BLRV and factors associated with elevated (≥5 µg/dL) blood lead levels among children aged 1–5 years in Thailand. A cross-sectional study was conducted using secondary data extracted from a national survey, implemented in 171 hospitals during October 2018–September 2019. Demographic characteristics and potential risk factors including lead-related industries were collected. Multilevel logistic regression was used. Of 3,184 children included in the survey, the BLRV was 6.9 µg/dL. Three significant risk factors were identified: living near a lead factory (adjusted odds ratio (AOR) 2.09, 95% CI 1.27–3.42), exposure to the manufacture of fishing tackle (AOR 4.39, 95% CI 1.54–12.50), and exposure to the manufacture of shot and ammunition (AOR 6.30, 95% CI 1.81–21.93). Despite a calculated BLRV of 6.9 µg/dL, we propose a BLRV of 5 µg/dL in Thailand based on guidelines from the United Kingdom. Surveillance of blood lead levels should be established among children at high risk of lead exposure.

Keywords: blood lead reference value, elevated blood lead level, preschool children, Thailand

Introduction

Lead is an important chemical with its properties suitable for use in many materials and industries, including pipes, weights, storage batteries, shot and ammunition, fishing tackle, cable covers, and protection from radiation.[1,2] Children and adults can be exposed to lead in various routes such as ingestion, inhalation, and skin absorption.[3,4] As a toxic metal, lead has harmful properties. Children are especially at risk, causing anemia, damage of the nervous system and limited growth and development.[1,4–6]

In the United States, repeated surveys of children aged 1–5 years have been conducted since 1976 as the part of National Health and Nutrition Examination Survey.[7,8] Part of the survey includes measurements of blood lead levels (BLL). Established in 1989, the Advisory Committee on Childhood Lead Poisoning Prevention (ACCLPP) have provided recommendations for prevention and control measures regarding childhood lead poisoning including the determination of the blood lead reference value (BLRV).[9] To identify children with a high blood lead level, ACCLPP use the 97.5th percentile of the population-based blood lead level surveyed among children aged 1–5 years.[8] Based on the National Health and Nutrition Examination Survey data during 2007–2010, the BLRV in the United States has been set to be 5 micrograms per deciliter (µg/dL) since 2012. However, the value was decreased to 3.5 µg/dL in 2021 based on the 2015–2018 surveys.[10] Since no level is considered to be safe, prevention and control measures should aim to prevent any exposure to lead. The BLRV would be the action level, guiding appropriate interventions to protect children from lead toxicity. However, determination of the BLRV varies depending on the baseline BLL of specific populations in each country.

Based on the Health Data Center in Thailand, it is reported that the incidence of lead poisoning among children aged 0–5 years in 2018 was 0.23 per 100,000 population.[11] However, this value may be an underestimate since all of the reported cases had severe symptoms and required treatment in hospital. Asymptomatic cases with a high BLL, or even those with mild symptoms, will be undiagnosed unless their blood is tested. In Thailand, a national survey on BLL among children, which assessed factors potentially causing lead exposure, was undertaken for the first time under the project "Smart Children Stay Safe and Stay Away from Lead" implemented in the 2019 fiscal year (October 2018–September 2019).[12] At that time, Thailand still used a BLRV of 10 µg/dL based on the U.S. Centers for Disease Control and Prevention recommended level in 1991.[10] This study aims to determine the BLRV among children aged 1–5 years, examine factors associated with an elevated blood lead level, and provide recommendations for lead prevention and control measures among children in Thailand.

Methods

A cross-sectional study was conducted using secondary data extracted from the "Smart Children Stay Safe and Stay Away from Lead" project.[12] The project was implemented to Well Child clinics in 171 hospitals in 48 provinces, covering all 12 health regions of Thailand and Bangkok, the capital city, in the 2019 fiscal year. The method of the survey is as follows. Quota sampling was used to recruit participants. Sampling was proportionate to the total number of children aged 1–5 years in each of the 13 areas. At least two provinces were included from each health region, except Bangkok, which included only one. A total of 48 provinces, selected by the health regions, asked governmental hospitals that had Well Child Clinics about their willingness to participate in the project. The study population included children aged 1–5 years who visited a Well Child Clinic in the selected hospitals. Written informed consent was obtained from the children's parents or legal guardians before collecting blood samples and other information using a structured questionnaire. Variables collected included demographic characteristics (age, gender, school attendance) and three potential risk factors that reflect a child's exposure to lead, namely (1) parent's or guardian's occupations (if related to lead), (2) if any work is related to lead at the home, and (3) residential location (within 30 meters of a factory or enterprise that manufactures lead). We also collected nine types of industries related to the abovementioned risk factors that may have caused exposure to the children, namely (1) jewelry manufacturing, (2) demolition and construction of buildings, (3) ship manufacturing, (4) paint manufacturing, (5) machinery and/or motor vehicle manufacturing, (6) battery storage, (7) shot and ammunition, (8) electronic waste, and (9) fishing tackle.

Figure 1. Map showing the 48 provinces of Thailand that were included in the national survey project, 2018-2019

Venous blood (2 mL) was collected and tested by Graphite Furnace Atomic Absorption Spectroscopy technique at the Reference Laboratory and Toxicology Center, Division of Occupational and Environmental Diseases.[13] A blood lead level (BLL) greater than or equal to 5 µg/dL was considered as elevated.

Data was analyzed using Microsoft Excel and Stata version 14. For the descriptive study, categorical variables were expressed as frequency and percentage. Comparisons between children with non-elevated and elevated BLL by each categorical variable were performed using a Chi-square test. The prevalence of BLL in the study population was adjusted for sampling weights. Summary statistics included mean and standard deviation, median with interquartile range (IQR), and range. The 97.5th percentile of the blood lead level was calculated in order to determine the BLRV. For the analytical study, a multilevel logistic regression model with independent variance–covariance structure of the random effects was fit to the data in which children were nested within hospitals and hospitals nested within provinces. Predictor variables included gender, age group (<3 versus 3–5 years), school attendance, lead exposure, and the nine aforementioned risk industries. Predictors with a *p*-value <0.2 were selected for the multivariable analysis. Adjusted odds ratio (AOR) with 95% confidence interval (CI) were presented with a significance level of 0.05.

Results

The participants in the study included 3,184 children aged 1–5 years from 48 provinces of Thailand (Figure 1). The population-based blood lead levels ranged from 0–42.8 µg/dL and the median was 1.1 µg/dL (IQR 0.4–2.2). Children aged 3–5 years had a higher BLL than those aged <3 years. The BLRV overall was 6.9 µg/dL (Table 1).

Table 1. Comparison of blood lead levels among children aged <3 years and 3–5 years, Thailand

Age group (years)	No. of children	Blood lead level (µg/dL)				
		Median	Range	IQR	Mean±SD	P97.5
1–5	3,184	1.1	0–42.8	0.4–2.2	1.7±2.3	6.9
<3	1,728	0.9	0–28.6	0.2–1.9	1.5±2.1	6.4
3–5	1,456	1.4	0–42.8	0.7–2.4	2.0±2.5	7.6

IQR: interquartile range, SD: standard deviation, P97.5: 97.5th percentile

Of 3,184 children, 52.0% were male and 56.8% were attending school. There were 606 (19.0%) children whose parent's or guardian's occupations were related to lead, 351 (11.0%) lived in a home where lead was used for manufacturing, and 420 (13.2%) lived near a factory or enterprise that manufactured lead. Manufacture of machinery and motor vehicles (10.6%) was the most common enterprise in which children were exposed to lead, followed by demolition and construction of buildings (6.0%), and paint manufacturing (5.6%) (Table 2). The proportion of children with an elevated BLL was higher in children aged 3-5 years and those who were attending school. Children whose parent's or guardian's occupations were related to lead or those who lived in a house where lead was used for manufacturing or whose house was located near a factory or enterprise which manufactured lead were significantly more likely to have an elevated blood lead level. If the enterprise involved making fishing tackle or ammunition then the likelihood of having an elevated blood lead level was significantly higher (Table 2).

Results of the univariate and multivariate analysis are shown in Table 3. Older age, attending school, having a parent or guardian whose occupation involved lead, living in a house where lead was used for manufacturing, living in a house near a lead factory or enterprise, exposure to manufacturing of fishing tackle, and exposure to manufacturing of shot and ammunition were significant risk factor on univariate analysis. On multivariate analysis, only three significant risk factors remained: living in a house located near a lead factory or enterprise (AOR 2.09, 95% CI 1.27–3.42), exposure to manufacturing of fishing tackle (AOR 4.39, 95% CI 1.54–12.5), and exposure to manufacturing of shot and ammunition (AOR 6.30, 95% CI 1.81–21.93).

Table 2. Comparison of epidemiological characteristics and lead-related risk factors among children with and without elevated blood lead levels (n=3,184)

Characteristic	Blood lead level n (%)			*p*-value*
	Total[†]	≥5 μg/dL	<5 μg/dL	
Gender				
Male	1,654 (52.0)	82 (5.0)	1,572 (95.0)	
Female	1,530 (48.0)	73 (4.8)	1,457 (95.2)	0.807
Age group (years)				
<3	1,728 (54.3)	66 (3.8)	1,662 (96.2)	
3–5	1,456 (45.7)	89 (6.1)	1,367 (93.9)	0.003
Attending school				
Yes	1,808 (56.8)	109 (6.0)	1,699 (94.0)	
No	1,376 (43.2)	46 (3.3)	1,330 (96.7)	<0.001
Risk factors of children's exposure to lead				
Parent's or guardian's occupations related to lead				
Yes	606 (19.0)	43 (7.1)	563 (92.9)	
No	2,578 (81.0)	112 (4.3)	2,466 (95.7)	0.005
Work related to lead at home				
Yes	351 (11.0)	32 (9.1)	319 (90.9)	
No	2,833 (89.0)	123 (4.3)	2,710 (95.7)	<0.001
Home located near lead factories or enterprises				
Yes	420 (13.2)	43 (10.2)	377 (89.8)	
No	2,764 (86.8)	112 (4.1)	2,652 (95.9)	<0.001
Type of industry related to children's exposure to lead				
Manufacture of machinery and motor vehicles				
Yes	337 (10.6)	18 (5.3)	319 (94.7)	
No	2,847 (89.4)	137 (4.8)	2,710 (95.2)	0.669
Demolition and construction of buildings				
Yes	191 (6.0)	11 (5.8)	180 (94.2)	
No	2,993 (94.0)	144 (4.8)	2,849 (95.2)	0.555
Paint manufacturing				
Yes	177 (5.6)	6 (3.4)	171 (96.6)	
No	3,007 (94.4)	149 (5.0)	2,858 (95.0)	0.347
Battery storage				
Yes	92 (2.9)	3 (3.3)	89 (96.7)	
No	3,092 (97.1)	152 (4.9)	2,940 (95.1)	0.467
Electronic waste				
Yes	73 (2.3)	6 (8.2)	67 (91.8)	
No	3,111 (97.7)	149 (4.8)	2,962 (95.2)	0.178
Fishing tackle manufacturing				
Yes	44 (1.4)	16 (36.7)	28 (63.3)	
No	3,140 (98.6)	139 (4.4)	3,001 (95.6)	<0.001
Jewelry manufacturing				
Yes	37 (1.2)	3 (8.1)	34 (91.9)	
No	3,147 (98.8)	152 (4.8)	2,995 (95.2)	0.357
Shot and ammunition manufacturing				
Yes	20 (0.6)	5 (25.0)	15 (75.0)	
No	3,164 (99.4)	150 (4.7)	3,014 (95.3)	<0.001
Ship manufacturing				
Yes	12 (0.4)	2 (16.7)	10 (83.3)	
No	3,172 (99.6)	153 (4.8)	3,019 (95.2)	0.057

[†]*This column displays the number and column percentage; *Chi-square test*

Table 3. Results of multilevel* univariable and multivariable analysis identifying factors associated with elevated blood lead levels among children aged 1–5 years, Thailand (n=3,184)

Characteristic	Blood lead level		Crude OR	95% CI	Adjusted OR	95% CI
	≥5 µg/dL	<5 µg/dL				
Age group (years)						
3–5	89	1,367	1.70	1.18–2.43	1.28	0.81–2.02
<3	66	1,662	Ref.		Ref.	
Attending school						
Yes	109	1,699	1.84	1.23–2.76	1.54	0.93–2.57
No	46	1,330	Ref.		Ref.	
Parent's or guardian's occupations related to lead						
Yes	43	563	1.64	1.10–2.46	1.03	0.63–1.69
No	112	2,466	Ref.		Ref.	
Work related to lead at home						
Yes	32	319	2.23	1.39–3.57	1.16	0.63–2.12
No	123	2,710	Ref.		Ref.	
Home located near a lead factory or enterprise						
Yes	43	377	2.87	1.87–4.41	2.09	1.27–3.42
No	112	2,652	Ref.		Ref.	
Exposure to electronic waste						
Yes	6	67	2.23	0.86–5.79	1.46	0.53–4.00
No	149	2,962	Ref.		Ref.	
Exposure to fishing tackle manufacturing						
Yes	16	28	7.53	2.97–19.05	4.39	1.54–12.50
No	139	3,001	Ref.		Ref.	
Exposure to shot and ammunition manufacturing						
Yes	5	15	12.07	3.67–39.64	6.30	1.81–21.93
No	150	3,014	Ref.		Ref.	
Exposure to ship manufacturing						
Yes	2	10	3.49	0.65–18.65	2.67	0.48–14.75
No	153	3,019	Ref.		Ref.	

**Intraclass correlation coefficient (ICC) province: 0.00; ICC hospital within province: 0.23*

OR: odds ratio, CI: confidence interval

Discussion

This is the first study to determine the blood lead reference value in Thailand using the 97.5th percentile of the population-based blood lead levels among children aged 1–5 years. The BLRV of 6.9 µg/dL from this study was slightly higher than that in the United States of 5 µg/dL (referenced from 2012–2021) and nearly twice as high as the BLRV of 3.5 µg/dL that was revised in 2021.[10] In the United Kingdom, data on lead exposure in the child surveillance system in 2021 led to a lowering of the BLRV to half the previous concentration, from 0.48 µmol/L (equivalent to 10 µg/dL) to 0.24 µmol/L (equivalent to 5 µg/dL).[14] There is no global standard BLRV. The United States and the United Kingdom are the only two countries that have provided large population-based lead surveillance data to give clear recommendations on the BLRV among children. Before the national survey in 2019, Thailand set the action level for BLL among children at 10 µg/dL.[12] Based on our findings, the BLRV for children in Thailand was 6.9 µg/dL. However, to be consistent with the recommendation from the United Kingdom, a BLL of 5 µg/dL may be more practical for use as the action level in Thailand.[14]

Regarding factors associated with elevated blood lead level, other studies reported that blood lead levels in children increase with increasing age, consistent with the results from our univariable analysis which showed that children aged 3–5 years had a significantly higher blood lead level than those aged <3 years, although the statistical significance disappeared in the multivariable analysis.[15–17] A possible explanation for this result is that children aged 3–5 years tend to be more active than those aged <3 years. This would increase their chance of lead exposure from the environment such as playgrounds. In 2019, a study surveyed the playground equipment in two popular parks in Bangkok and found that 14 of

24 selected pieces of equipment contained lead levels greater than 10,000 parts per million.[18]

Results of the univariable analysis demonstrated that the three main exposure variables (parent's or guardian's occupations were related to lead, living in a house where lead was used for manufacturing, and living in a house near a lead factory) increased the risk of having a high blood lead level. However, only house location was significant in the multivariable analysis. These findings are consistent with other studies. Children whose parents had lead-related occupations had a significantly higher risk of elevated BLL than other children.[19–21] Exposure can occur from contaminated clothing. A study from China showed that children's blood lead level decreased as the distance between the children's house and the lead factories increased.[22] Another study from Italy reported that blood lead levels among children living in communities free from factories that use lead were significantly lower than communities whose economy was based on home-operated artistic pottery production (using lead).[21]

According to lead-associated industries, we found that exposure to manufacturing of shot and ammunition and fishing tackle were statistically significant risk factors. This is consistent with reports in 2023 that children of employees at an ammunition plant in Anoka, Minnesota had higher BLL, possibly due to take-home lead.[23] A study in Thailand reported that the mean BLL among children residing in fishing communities was about 2.5 times higher than children in other communities.[24]

This study has some limitations. First, selection bias could have occurred because the data were derived from a hospital-based survey using quota sampling. However, the proportional quotas and weighted analyses based on the sampling process could minimize this problem since the method would help generate a sample that was more likely to match the geographical distribution of the population. Second, the study sample included children visiting hospitals and therefore could potentially have higher blood lead levels than those in community. However, this did not adversely impact the calculated BLRV. Third, subject recruitment may have varied by health region; however, the manual for project implementation was developed to be used as the standard operational protocol for every health region. Finally, data of some variables, such as weight and height, underlying disease, and children's behavior had many missing values and were therefore excluded from the analysis. These omitted variables may potentially be significant factors influencing elevated BLL.

Public Health Actions and Recommendations

Lead exposure can seriously affect children's health and wellbeing, causing brain damage and growth and development delay. Based on guidelines recommended by the Advisory Committee on Childhood Lead Poisoning Prevention, the BLRV for children in Thailand should be set at 6.9 µg/dL. However, to be consistent with the recommendation from the United Kingdom, a blood lead level of 5 µg/dL would be a more appropriate reference level to be used in Thailand. Additionally, in order to control and prevent children from lead exposure, health officials should work in collaboration with their network partners, such as the Ministry of Industry or the Ministry of Labor, to provide health literacy and increase awareness among parents working in factories or enterprises that use lead for manufacturing to prevent take home lead exposure in children. Exposure surveillance of blood lead levels should be set up in order to detect elevated blood lead levels among children living in high-risk areas or having a high risk of lead exposure, such as those whose parents or guardians have occupations related to lead.

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The Grammar of Science: Do You Get What You Measured?

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Old sayings—"You get what you measured.", "What gets measured gets done/managed.", "You can't improve what you don't measure.", etc. So…when conducting a research study, are you sure that the research instrument measure what it is intended to?

Research instrument is a tool used to collect, measure, and analyze data related to the research question of interest. Designing or choosing an instrument is the initial process after conceptualization of research questions and operationalizing concepts or constructs of the instrument.[1] When selecting or developing a research instrument, researchers must be assured that the instrument possesses quality characteristics including its reliability and validity, basing on conceptual framework of the study. Research tools can be in any formats: questionnaire, interview form, direct-indirect observations laboratory test, etc. We will now focus on validity of questionnaire or test battery designed to be administered in order to obtain a comprehensive assessment of a particular factor or phenomenon.

Validity of Research Instrument

There are three types of validity: construct validity, content validity and criterion validity. Construct validity is appraised when researchers desire to draw an inference from scores (obtained from the questionnaire or test) that can be grouped under the label of a particular construct while content validity assesses whether the items in the questionnaire or test adequately represent each specific construct of interest. Criterion validity is usually done when researchers want to draw an inference whether or not scores obtained from the new developed measurement/test are associated with, or could predict, other observable variable that has practical importance.[2–5]

As an example, when designing a questionnaire to measure quality of life (QOL), researchers may perform in different steps. The process usually starts with identifying and defining the constructs of QOL based on hypothetical or theoretical concept(s) of QOL, say—physical function, psychological function, social function, and spiritual function.[6] Next step is writing up the elements (questions or times) for the questionnaire by taking into consideration of "content validity" in terms of item relevancy, representativeness, necessity, and completion of the concept(s) supposed to be measuring. In order to ensure the "construct validity", the questionnaire should be assessed whether it actually covers and measures the four desired constructs of QOL. Moreover, the measurement scores obtained from the questionnaire could be tested for "criterion validity" ensuring that it is theoretically and logically accurate with the desired constructs by associating the scores with a certain criterion concurrently measured (concurrent validity) or making prediction with a certain outcome in the future (predictive validity); e.g., QOL scores may be correlated with health perception at present time and health improvement status thereafter.

Construct validity can be viewed as an overarching term to assess the validity of a research instrument as it incorporates other forms of validity (i.e., content validity, and criterion validity).[5] That means confirming construct validity covers the process of testing content validity, criterion validity and others.

Types of Construct Validity: Convergent Validity & Discriminant Validity

Construct validity is one of the most important concepts in measurement theory, especially when researchers want to measure a variable that is not itself directly observable. Many times, the variables to be measured in a study is not concrete or obviously observable. Not only research in social sciences, psychology and education, but also those in medicine and public health measure and analyze abstract concepts; for example, pain, anxiety, quality of life, and satisfaction to a healthcare program.[7–10] It is thus important to evaluate whether the research instrument is, in fact, measured the "hidden" or "latent" variables it is supposed to measure or not.

Researchers typically establish construct validity by correlating a measure of a construct with the other measures that should, theoretically, be associated with it (so-called convergent validity) or vary independently of it (so-called discriminant validity or divergent validity).[11] Convergent validity is observed when the constructs expected to be related are shown related. On the other hand, discriminant validity is observed when the constructs that should not be related are, in fact, unrelated.[7,9,12] In appraising construct validity of QOL, the convergent validity would assess that QOL is, in fact, related to a few overlapped concepts, e.g., life satisfaction or self-appraisal. Discriminant validity would ensure that QOL does not related to or has very poor relationship with the non-overlapping factors, e.g., ethical or political ideation.[7,13] That means, the questionnaire or test should possess two qualities; the test should measure "what it is to measure" and does not measure "what it should not be measured". The research instrument that shows such quality is regarded as having excellent construct validity.[7,9]

It should be noted that convergent validity is a type of construct validity and it is not the same as concurrent validity which is a type of criterion validity. Both convergent and concurrent validity are assessed by examining the correlation between the scores from two measurements. Concurrent validity compares a new measurement with a well-established measurement in attempt to present the criterion validity. On the other hand, convergent validity tests the relationship between two new measurements or two related constructs.[3]

Researchers can determine construct validity of a research instrument by different methods. Simple analytical methods include: comparison of the scores obtained from the instrument among known groups (known-groups validity), or correlation with scores from other instrument/test that measures similar qualities or constructs. Other advanced methods include: factor analysis, multitraits-multimethods (MTMM), structural equation modeling (SEM), etc.

Construct Validity & Known-groups Validity

A simple method to provide an evidence of construct validity is to use "known-groups validity" to confirm the constructs. The method is to compare scores obtained from the questionnaire/ test between independent groups (or extreme groups) with vs. without the characteristics related to the constructs being measured. The expectation of the comparison is to be able to detect hypothesized differences between these known independent groups. If scores obtained from the measurement can effectively differentiate between the groups, then the construct validity may be established.[14]

Statistical techniques used to compare different known groups could be Independent samples t-tests, ANOVAs, and non-parametric tests. Researchers can simply assess construct validity by using t-test to compare QOL physical function scores between those who apparently show good physical function vs. those who do not. Here are some examples in literature showing that the researchers might compare QOL scores among different subgroups in several known conditions. A study assessing validity for a QOL instrument employed known-group validity to discriminate among elderly groups known to be different in varying levels of aged-care needs and self-reported health.[15] The other study assessed construct validity of QOL score among elderly groups with different education levels and the presence or absence of the chronic conditions (dementia, depression, and dizziness).[16] Another study compared generic measures of QOL among different subgroups of adolescents from different contexts, subgroups of outpatient treatment for mental disorders and subgroups of students with low and high human development.[17]

Construct Validity & Factor Analysis

Construct validity can be addressed by a factor analysis. Factor analysis is typically used to analyze interrelationships within a set of variables or to confirm the construction of a few hypothetical variables, so-called factors (domains, dimensions, components).[2] Historically, it was noted by measurement experts that "construct validity" has been known as 'factorial validity'.[10,18,19]

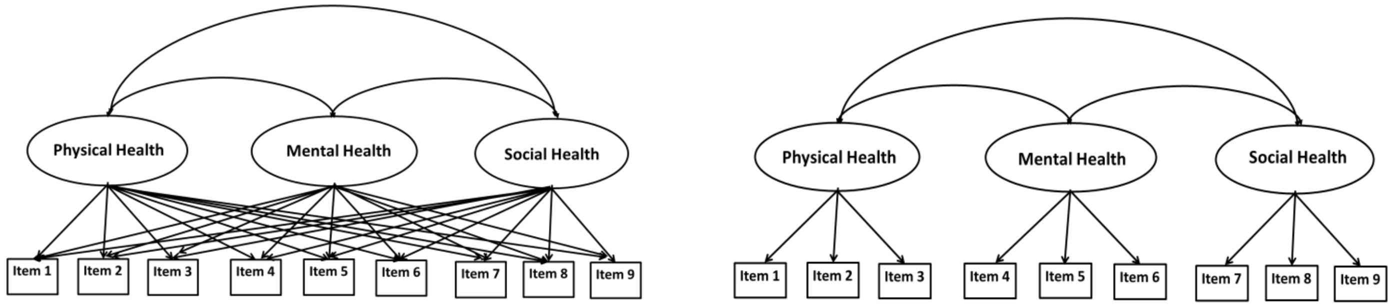
Factor analysis answers the question asked by construct validity. In general, the method is to postulate common latent (hidden) factor(s) from the intercorrelations among the observed variables (i.e., items in the questionnaire).[2] There are two types of factor analysis, exploratory factor analysis (EFA) and confirmatory factor analysis (CFA).[2,20] Based on the interrelationships among a set of observed variables/items, EFA answers: what are the hidden factors (constructs) and whether they are the factors (constructs) that the questionnaire/test is supposed to be measured. As EFA is the technique to identify the factor structure or model hidden in a set of observed variables; it is thus considered as a "theory-generating" procedure. On the other hand, CFA answers whether different sets of variables/items are correlated together according to the different hypothetical factors (constructs) that the researchers used as basis when they developed that questionnaire/test. CFA is thus considered as a "theoretical-testing" approach.[2,20–22]

The analytic question of EFA is: "What are the underlying or latent constructs that could have produced from the observed pattern of covariances (or correlations) among the variables/items?" EFA results in factor loadings which are derived from correlations between a set of variables/items and a hypothetical construct. Typically, a minimum number for factor loading ranging between 0.30–0.55 is considered to be a strong factor loading coefficient. Based on EFA results, the constructs (latent variables) are established by deducing names for the factors based on the content (i.e., wording) of the items (observed variables) that load heavily upon them.[22]

The analytic question for CFA is: "Are the covariances (or correlations) among a set of variables/items consistent with a hypothesized factor structure?" That means, CFA confirms the relationships between observed variables/items with factors (constructs) that is generally based on a strong theoretical or observational foundation that researchers used to specify an exact factor structure in advance. In general, CFA restricts which variables/items will load on which factors, as well as which factors will be correlated.[22]

As an example, based on literature review on theories related to QOL, researchers may decide to develop a QOL measurement composing of three main constructs, i.e., physical health, mental health, and social health.[6,22–24] The analysis of EFA examines interrelationships among all items with the three "hidden" constructs while CFA confirms interrelationships among a set of items with the specific pre-planned construct. The three constructs may be independent or may be related to one another depending on the researchers' conceptualization of the QOL constructs (Figure 1).

Several techniques can be selected to perform factor analysis including, for examples, principal axis factoring, principal components analysis, image factor extraction, alpha factoring.[22] Here are some examples in literature that employ factor analysis to determine construct validity. A study determined the construct validity using EFA to show the existence of four dimensions: physical, psychological, social and spiritual domains.[25] In another study, after reviewing several theories of QOL, the researchers employed EFA to identify a parsimonious and psychometrically sound solution factors of QOL and subsequently confirmed the factors using CFA.[21]



(a) Exploratory Factor Analysis Approach

(b) Confirmatory Factor Analysis Approach

Figure 1. Factor Analysis Models

Construct Validity & Multitraits-multimethods (MTMM)

MTMM was introduced by Campbell and Fiske in 1959.[9] MTMM assesses the common "set of associations" among several traits, each being measured via several methods. Traits could be hypothetical constructs while methods can be different procedures of data collection method, different groups of data provider, or different types of items in the measurement/test.[24,26–28] MTMM evaluates trait-related and method variances through the correlations among scores obtained from multiple constructs and multiple methods.[4] As an example, shown in Figure 2, researchers want to assess correlations among scores of three traits (constructs) of QOL (physical, mental and social) as scaled by two methods (self-rating and caregiver rating).

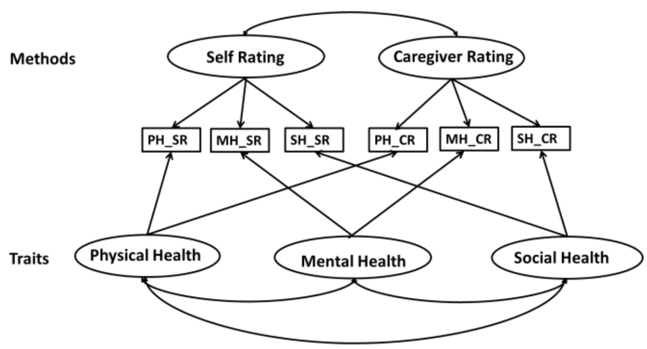


Figure 2. Multitraits-multimethods approach

MTMM involves a correlation matrix customized to enhance the evaluation of construct validity in terms of the discriminant and convergent validity. As shown in Figure 3, MTMM will assess: (1) the relationship between the same constructs (traits) and the same methods (i.e., reliability of the measurement, shown in the diagonal), (2) the relationship between the same constructs (traits) using different measurement methods (i.e., convergent validity); and (3) the relationship between different constructs using different methods of measurement and between different constructs with same method (i.e., discriminant validity). In determining whether the questionnaire/test has a good construct validity or not, the correlations for convergent validity should be high while the correlations for the discriminant validity should be low.[26] As a rule of thumb, an r value of >0.50 is generally considered sufficient to suggest convergent validity. It should also be noted that correlations among related constructs should be higher than those of unrelated constructs.[12]

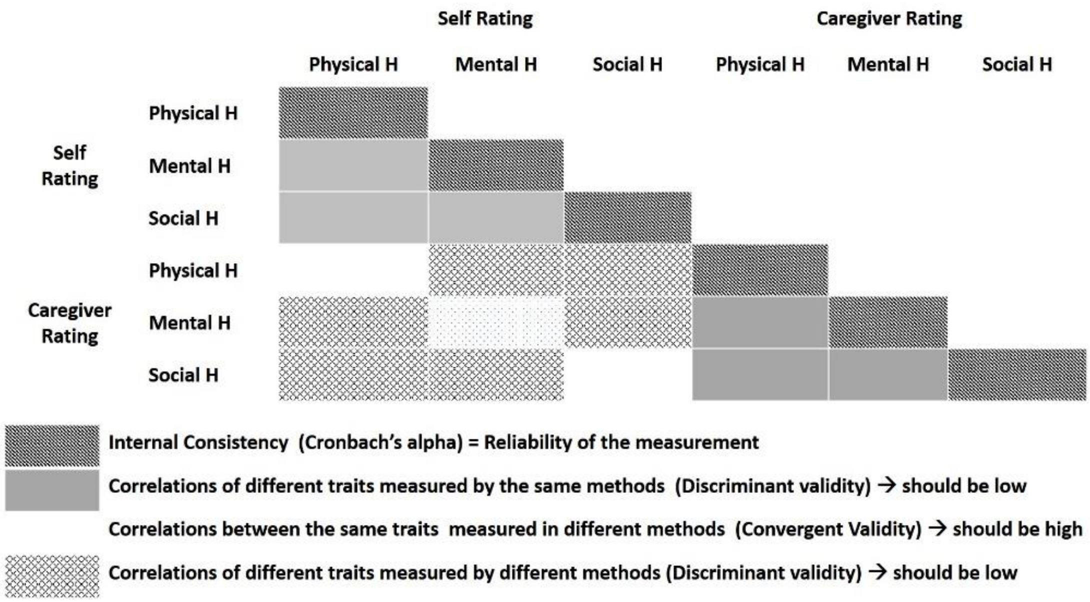


Figure 3. Content validity ratio (CVR) based on number of experts evaluated the item essential

Some examples of MTMM approach used to assess construct validity in literature. A study examined the convergent and discriminant validity of the four domains of the WHO-QOL-BREF by using MTMM approach; each participant filled out the WHO-QOL-BREF questionnaires of four traits (physical, psychological, social and environmental functions) using four different scaling methods (Likert-type scale, visual analogue scale, pie scale, and partner rating).[27] The other study employed MMTM to assess construct validity of children's QOL questionnaire with four subscales/constructs (physical, emotional, social, school functioning) with two methods (child-self report and parent-proxy report.[23]

MTMM can be used to assess construct validity of the new research instrument against the constructs of the standard instrument. As an example, a study employed MTMM to assess the convergent and discriminant validity of QOL which composed of three traits/constructs or subdimensions (i.e., physical, social, and psychological well-being) and two methods (i.e., two QOL instruments, standard WHO-QOL and new Roh QOL developed for middle age adult).[24] Another example, in a study on developing a translated and culturally adapted version of QOL questionnaire, the construct validity was first assessed by using EFA and then appraised for the convergent and discriminant validity using MTMM.

The study assessed three domains for QOL (physical functioning, emotional well-being, social functioning) with two methods (i.e., two questionnaires, new translated QOL and standard WHO-QOL).[28]

Conclusion

Researchers should be assured that they really measure what they intend to measure. That is, the questionnaire or other measuring tools developed, adapted or adopted to be used in their study should possess good construct validity. If the instrument lacks construct validity, the study results will be difficult to interpret.[11] To demonstrate construct validity may not be done in one single analysis because it is also related to content validity and criterion validity.[3]

Several factors can be threats to construct validity. The most important aspect of construct validity is about possessing clear and precise conceptual and operational definitions of the constructs intended to measure.[3] Definition of a construct can invalidate the measurement if the definition is incomplete, inexact, unclear, mislabeling, too broad, or too narrow. Construct confounding, which would lead to unreliable scores, may occur when other constructs overrule or mask of the effects of the measured construct.[7] For example, when assessing QOL constructs which could be affected by several factors (e.g., disease severity, social status), and if those factors were not taken into account, one might face construct confounding problem.[3,7]

You may have a great idea and a very good research question, but it is even more critical to ask yourself: "What is the quality of my research instrument?" "Is it reliable and valid?" "Does it measure what I want to measure to answer my great research question?"

Suggested Citation

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