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A Food Poisoning Outbreak in a School from Progressive Contamination of Norovirus, Amnat Charoen Province, Thailand, February 2025

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Abstract

On 13 Feb 2025, students and staff at School A in Hua Taphan District, Amnat Charoen Province, Thailand, developed gastroenteritis symptoms. An investigation was conducted to confirm the diagnosis, describe outbreak characteristics, identify possible sources and risk factors, and provide recommendations. A suspected case was an individual present at the school between 11–24 Feb 2025 who experienced three or more loose or liquid stools within 24 hours or at least one episode of vomiting. Data was collected via questionnaires and hospital records. Rectal swabs and stool samples were tested, and the environment was assessed. A retrospective cohort study was conducted using multivariable Poisson regression with robust error variance to calculate adjusted relative risks (ARR). The attack rate was 30.2% (142/470). Common symptoms were nausea (85%), abdominal pain (79%), and vomiting (76%). The epidemic curve indicated a point-source exposure followed by secondary transmission. Norovirus was detected in 71.4% of clinical samples, including one asymptomatic food handler. The chicken rice meal served on 11 February, had the highest ARR of 4.37 (95% confidence interval (CI) 1.12–17.10). Students served later (grades 4–6) had a significantly higher risk compared to the early serving group (ARR 2.17, 95% CI 1.37–3.43), suggesting progressive contamination. The epidemiological and laboratory results suggested that the chicken rice meal, was likely contaminated by an infected asymptomatic food handler, which was the source of the norovirus outbreak. The study recommendations included improving food-handling practices, strengthening hand hygiene infrastructure, and ensuring regular maintenance of the water treatment system.

Keywords: norovirus, foodborne and waterborne outbreak, outbreak investigation

Introduction

Foodborne illnesses remain a major global public health concern, with the World Health Organization estimating 600 million cases and 420,000 deaths and the loss of 33 million disability-adjusted life years (DALYs).[1]

Norovirus is the leading cause of acute gastroenteritis worldwide. It is estimated to cause 685 million cases annually, including 200 million children under five. The virus is associated with approximately 200,000 deaths each year, particularly affecting young children, older adults, and individuals with compromised immunity. In addition to its health impact, norovirus imposes a substantial global economic burden, with annual costs estimated at 60 billion US dollars due to healthcare expenses and productivity losses.[2]

Thailand similarly faces a considerable burden; in 2024, the country reported 130,444 food poisoning cases, corresponding to an incidence of approximately 200 per 100,000 population.[3] Norovirus is a leading cause of acute gastroenteritis in Thailand, with schools frequently serving as outbreak sites. Most clusters occur during the cool season (September–February) when close contact and low temperatures enhance transmission. From 2017–2021, about three-quarters of reported outbreaks were linked to schools.[4,5] Outbreaks spread rapidly via person-to-person and foodborne routes, often affecting 10.0–30.0% of students, causing vomiting, diarrhea, and dehydration.[6] These events disrupt learning through absenteeism and temporary school closures, highlighting the need for strict hygiene, early case isolation, and environmental cleaning to limit spread.[7,8]

On 13 Feb 2025, the Department of Disease Control (DDC) was notified of a suspected foodborne illness outbreak at a school in Hua Taphan District, Amnat Charoen Province, Thailand, prompting the deployment of a Joint Investigation Team (JIT) comprising of DDC and local health staff. Conducted from 14–17 Feb 2025, the investigation aimed to confirm the diagnosis and outbreak, describe the epidemiological characteristics, identify potential sources and transmission risk factors, and recommend appropriate control measures.

Methods

Epidemiologic Study

A suspected case was defined as any student or school staff present at the school between 11–24 Feb 2025 who experienced three or more loose or liquid stools within 24 hours or at least one episode of vomiting. A confirmed case was defined as a suspected case with a laboratory-confirmed norovirus detected from a fresh stool or rectal swab sample, while an asymptomatic case referred to a person without gastrointestinal symptoms who tested positive for norovirus using the same diagnostic methods.

Active case finding was conducted through multiple approaches: students who visited the hospital were scheduled for follow-up interviews and questionnaires; room-by-room surveys were carried out by the JIT in every classroom; school staff received online health questionnaires; and for absent students, Google Form questionnaires were distributed via the class LINE group, a mobile messaging application widely used in Thailand, by homeroom teachers.

Data were collected using semi-structured questionnaires. For preschool students, questionnaires were completed by their parents, while older students completed them under the guidance of the JIT and teachers. Information collected included demographic characteristics, symptomatology, food items and consumption detail (including quantity, categorized into five levels: not eat, eat less than half, eat about half, eat more than half, and eat all) and source of drinking water.

A retrospective cohort study was conducted among all students and staff who were present at the school during lunch on 11 Feb 2025, for which data were collected using structured questionnaires to identify potential sources and risk factors associated with the outbreak. The estimated sample size required was 202 participants, based on exposure and attack rate assumptions from similar foodborne outbreaks reported in Thailand.[9,10] Descriptive analysis summarized demographic and clinical characteristics as proportions for categorical variables and medians with interquartile ranges for continuous variables. For the cohort study, risk ratios (RRs) with 95% confidence intervals (CIs) were calculated for each food item using a Poisson regression model with robust standard errors. This study used Poisson regression due to its ability to provide adjusted risk ratios, which is more understandable given that the disease was not rare among the affected population in this event.[11] Multivariable analysis was performed using the same model to calculate adjusted RRs, focusing on food items served during the most suspected meal and including variables with p-value <0.20 from the univariable analysis or those deemed epidemiologically relevant. Statistical significance was defined as p-value <0.05, and all analyses were conducted using R software (version 4.4.1) with the *tidyverse* package (version 1.3.1).[12]

Environmental Study

This study conducted environmental inspections of the school kitchen, food preparation areas, dishwashing stations and water supply system using the standard water and sanitation safety checklist from the Department of Health.[13] A walkthrough survey was carried out to observe hygiene practices, food storage conditions, and overall sanitation. Food handlers were interviewed to gather information regarding raw material sourcing, cooking procedures, and water collection and usage during meal preparation.

Environmental sampling included the collection of water samples from various risk points around the school. Coliform screening was conducted using two field test kits: the A.11 test for drinking water and the SI-2 test for food, utensils, and hand samples. These samples were tested for coliform bacteria using the SI-2 test kit, a peptone-lactose-bromocresol solution that detects lactose-fermenting bacteria through gas production and acidification. Residual chlorine levels in water samples were measured using the O-31 test, which contains an orthotolidine-arsenate solution that reacts with free residual chlorine. In addition, water and ice samples intended for drinking were collected for multiplex polymerase chain reaction (PCR) to detect key viral gastrointestinal pathogens, including norovirus, rotavirus, and adenovirus, while bacterial pathogens were assessed using bacterial culture.

Laboratory Study

For laboratory testing, stool and rectal swab specimens were collected approximately 10.0% from symptomatic cases who had not yet received antibiotics. Fresh stool samples were preferred because they provide higher pathogen detection sensitivity compared with rectal swabs, which were used only when stool could not be obtained.[14] All food handlers were also included in the laboratory investigation. All specimens were sent to the Bamrasnaradura Infectious Diseases Institute or the National Institute of Health for bacterial culture and PCR analysis to detect potential viral and bacterial gastrointestinal pathogens.

Results

Epidemiologic Study

A total of 470 individuals (430 students and 40 staff) were present at the school, which serves kindergarten level 2 through grade 6. The response rate to the questionnaire was 80.2% (377/470). Active case finding identified 142 cases. Of these, 139 were symptomatic students, one was a symptomatic staff member, and two were asymptomatic food handlers. Thirteen cases met the confirmed case definition, 127 were classified as suspected cases, and two were asymptomatic. Most cases managed their illness at home (68.0% did not seek medical care), while 29.2% visited the outpatient department and 2.8% required brief hospitalization.

The crude attack rate was 30.2% (142/470). Attack rates were lowest among preschoolers at 12.0–13.8%, increasing with age to 56.8% among grade 6 students, while only 2.5% of staff were affected. The median age was 9 years (interquartile range 7–11 years), and the male-to-female ratio (M:F) was 1.0:1.5. The most common symptoms were nausea (84.3%), abdominal pain (78.5%), and vomiting (76.0%), followed by fever (36.5%) and diarrhea (28.4%).

The first case developed symptoms at approximately 12:00 PM on 11 Feb 2025. The number of cases increased rapidly, peaking between 06:00 PM and 12:00 AM on 12 February, and declined sharply after 13 Feb 2025, consistent with the epidemiological pattern of a point common-source outbreak. In total, 47 cases (33.1%) developed symptoms 30–36 hours after the lunch meal on 11 February, aligning with the main surge in the epidemic curve (Figure 1).

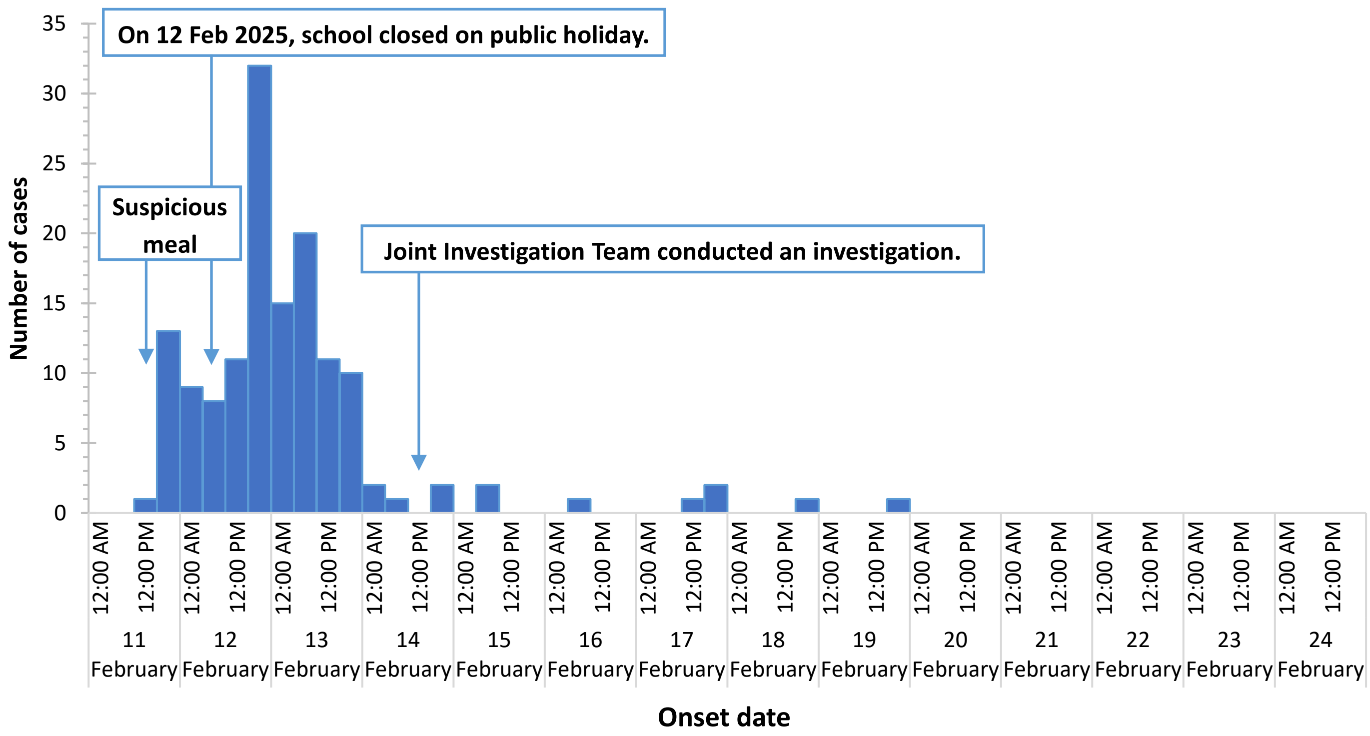


Figure 1. Number of food poisoning cases at a school in Hua Taphan District, Amnat Charoen Province, 11–24 Feb 2025, Classified by Date of Symptom Onset (n=142)

The highest attack rate was observed among those who consumed chicken rice (67.5%, 131/194). The school was closed on 12 Feb 2025, due to a public holiday, and no meals were served. The univariable analysis showed that the chicken rice meal had the strongest association with illness (crude RR 6.65, 95% CI 1.72–25.65). Meal-service timing also influenced risk: students in the intermediate serving group had twice the risk of illness (crude RR 2.00, 95% CI 1.25–3.19), and those in the late serving group had an even higher risk (crude RR 2.39, 95% CI 1.51–3.77) compared with the early serving group. In the multivariable model, the chicken rice meal remained independently associated with illness (adjusted RR 4.37, 95% CI 1.12–17.10), and elevated risks persisted for both the intermediate (adjusted RR 1.76, 95% CI 1.10–2.82) and late serving groups (adjusted RR 2.17, 95% CI 1.37–3.43) (Table 1).

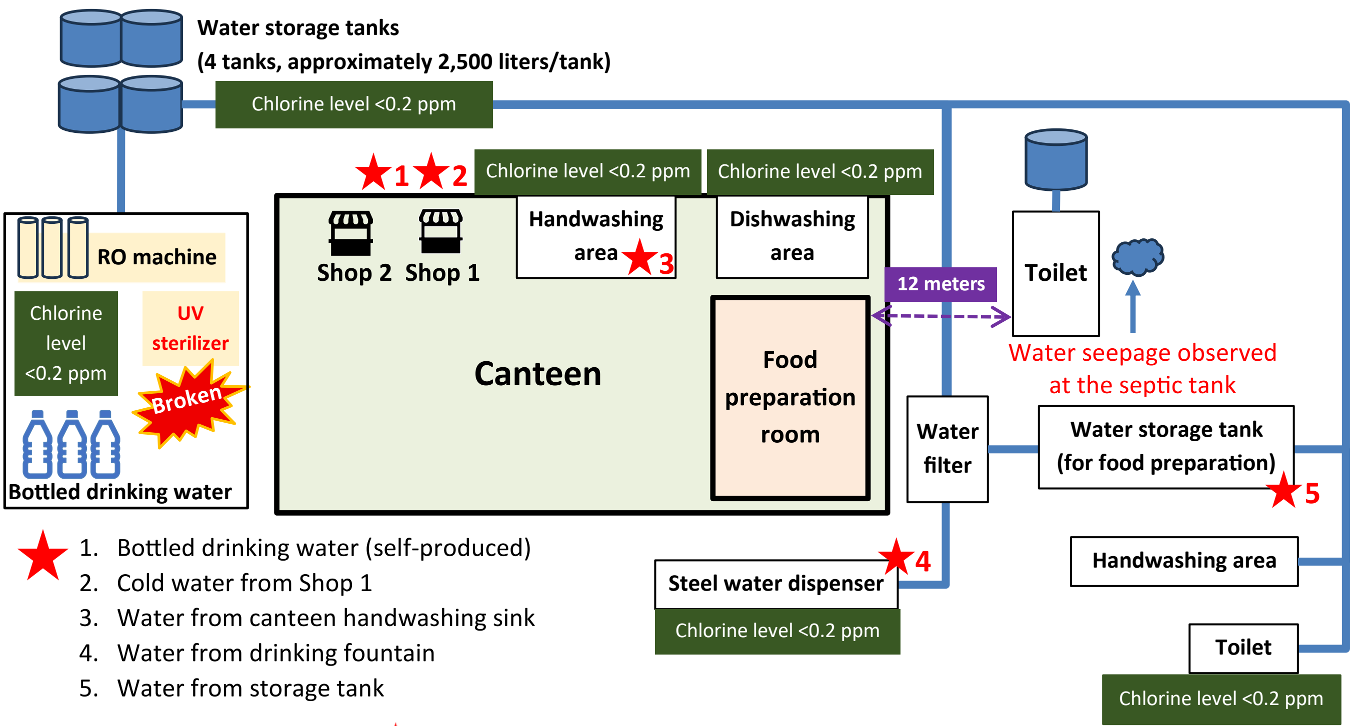
Table 1. Crude and adjusted relative risks of food and water exposures associated with food poisoning at a school, Amnat Charoen Province, February 2025

Items	Exposed	Non-exposed	Crude RR	*P*-value	Adjusted RR	*P*-value
	Attack rate (case/total)	Attack rate (case/total)	(95% CI)		(95% CI)	
Chicken rice	67.5% (131/194)	6.5% (2/31)	6.65 (1.72–25.65)	<0.01*	4.37 (1.12–17.10)	0.03*
Steel dispenser water	44.8% (13/29)	63.6% (129/206)	0.80 (0.5–1.29)	0.36	0.80 (0.50–1.28)	0.35
Filtered water	63.7% (121/190)	46.7% (21/45)	1.22 (0.84–1.79)	0.30	1.17 (0.75–1.82)	0.50
Early serving group (Preschool 2–3)	25.8% (17/66)	81.0% (124/153)	Reference		Reference	
Intermediate serving group (Grade 1–3)	69.4% (59/85)	61.2% (82/134)	2.00 (1.25–3.19)	<0.01*	1.76 (1.10–2.82)	0.02*
Late serving group (Grade 4–6)	95.6% (65/68)	50.3% (76/151)	2.39 (1.51–3.77)	<0.01*	2.17 (1.37–3.43)	<0.01*

Adjusted for chicken rice, steel dispenser water, filtered water, and meal service timing. RR: risk ratio. CI: confidence interval.

Environmental Study

Groundwater served as the school's primary water source. Drinking water passed through a reverse osmosis system and an ultraviolet (UV) sterilizer, although the UV unit had been nonfunctional for two weeks and maintenance was suboptimal. Water used in the kitchen came from a separate line with ceramic filtration. Soap was not available at handwashing stations in the kitchen or nearby toilets. Students did not clean their food trays thoroughly after meals; visible food residues and moisture were often left on the trays. After use, trays were placed in a single stack while still wet, without adequate drying or sanitization, and were later reused for the next meal. There was no separation between cutting boards and knives used for raw meat and vegetables, presenting a risk for cross-contamination. The school had only two food handlers, each with over 20 years of experience, but neither had received formal food safety training (Figure 2).



Specific water marked with star symbols (★) correspond to the sampling points assessed during the investigation and represent the main exposure routes for students and staff. RO: reverse osmosis. UV: ultraviolet.

Figure 2. Layout of the canteen and water supply system at School A, Hua Taphan District, Amnat Charoen Province, Thailand

Raw chicken meat was pre-chopped at the supplier before delivery to the school. No cold storage was available at the school; therefore, ingredients were used on the same day of delivery, and cooking began immediately upon arrival in the morning.

On 11 February, the chicken rice lunch was prepared as follows. Food handler 1 rinsed raw chicken prior to cooking and later handled cooked chicken during portioning and serving. Food handler 2 prepared rice using grains stored in the kitchen. The rice was rinsed three times using water from the ceramic-filtered supply, then cooked in the chicken broth using a rice cooker. After cooking, the rice was left in the unplugged cooker for approximately one hour.

At 09:00 AM, final food assembly was performed. With gloves on, food handler 1 portioned the chicken onto individual trays, and food handler 2 scooped the rice. Teachers assisted with distribution. Preschoolers were served at approximately 10:30 AM, followed by grades 1–3 around 11:00 AM, and grades 4–6 around 11:30 AM.

Multiplex PCR detected no pathogens in water, ice, or kitchen tools such as knives, cutting boards, and trays. The drinking-water system showed no contamination by the A.11 test. Coliforms were detected in 70% (7/10) of surface and equipment samples, including food trays, spoons, plates, a water tap, one food handler's hand, and the handwashing sink in the girls' restroom. Several water sampling points around the school showed residual chlorine levels of <0.2 ppm, including outlets near Shop 1, Shop 2, the handwashing and dishwashing sinks, and the drinking water dispenser.

Laboratory Study

A total of 14 rectal swabs and stool samples were collected, including 12 from symptomatic cases and two from asymptomatic food handlers. Multiplex PCR detected at least one gastrointestinal pathogen in 92.9% of samples, and norovirus detected in 71.4% of the samples (Table 2). Food handler 1 tested positive for norovirus.

Table 2. Laboratory test results of rectal swab and stool samples from cases and food handlers, Hua Taphan District, Amnat Charoen Province, Thailand, February 2025

Pathogen	Cases (n=12) n (%)	Food handlers (n=2) n (%)	Total (n=14) n (%)
Any pathogen (PCR)	11 (91.7)	2 (100.0)	13 (92.9)
Norovirus	9 (75.0)	1 (50.0)	10 (71.4)
Astrovirus	3 (25.0)	-	3 (21.4)
P. shigelloides	2 (16.7)	1 (50.0)	3 (21.4)
Sapovirus	1 (8.3)	-	1 (7.1)
***Aeromonas* spp.**	1 (8.3)	-	1 (7.1)
EPEC	1 (8.3)	-	1 (7.1)
EAEC (culture)	1 (8.3)	1 (50.0)	2 (14.3)

PCR: polymerase chain reaction, EPEC: enteropathogenic Escherichia coli., EAEC: enteroaggregative Escherichia coli.

Action Taken

On 17 Feb 2025, after confirming norovirus in an asymptomatic food handler, the school was advised to immediately exclude the affected individual from food preparation. Hua Taphan Hospital provided risk communication and handwashing education to staff and students, while the investigation team reinforced essential hygiene practices and avoiding prolonged room-temperature holding of cooked food. The tray-drying method was improved by spreading trays under sunlight to reduce moisture. Chlorine was added to the school's water system to maintain residual chlorine levels at 0.5–1 ppm during the outbreak, with a plan to return to the routine maintenance level of 0.3–0.5 ppm once the situation was controlled.

Discussion

This study confirmed a norovirus outbreak among students and staff at the school, with epidemiologic and laboratory evidence indicating that the chicken rice served on 11 February, was the most likely vehicle, contaminated during preparation by an asymptomatic food handler infected with norovirus.

The identification of an infected, but asymptomatic handler was a critical finding. Norovirus is highly contagious, requiring a very low infectious dose (<100 viral particles) to cause illness.[15] Asymptomatic infection is common, with studies estimating that approximately 30% of norovirus infections present without symptoms.[16] Asymptomatic individuals can shed the virus in viral loads comparable to symptomatic cases and for up to 3–4 weeks.[17]

The observed timing of symptoms was consistent with the incubation period of norovirus, which ranges from 12 to 48 hours with a median of 33 hours.[18] A trailing distribution of cases from 14–18 February suggests subsequent secondary person-to-person transmission, a pattern commonly observed in school norovirus outbreaks given the virus's high transmissibility and environmental persistence.[19] The outbreak was characterized by upper gastrointestinal symptoms, particularly nausea and vomiting, a pattern typical of norovirus infection and distinct from the diarrhea-predominant presentation more commonly seen in bacterial foodborne illnesses.[20]

The chicken rice meal served on 11 February, was the most plausible primary source of infection, supported by a strong epidemiologic association and a clear biological link to food handler 1, who tested positive for norovirus. This handler performed several high-risk tasks, including rinsing raw chicken, handling cooked chicken, and serving cooked food items. Given this workflow, post-cooking contamination of the chicken rice was highly likely. A graded increase in risk was observed across the meal-service schedule, with students served later experiencing higher illness rates. Because norovirus does not multiply in food, this pattern is consistent with progressive contamination during the serving process, likely due to increasing viral transfer from food handler 1 as meal distribution progressed.[21]

Although norovirus was not detected in the water supply, extensive coliform contamination on 70% of sampled surfaces—including food trays, utensils, and the hands of a food handler—indicated substantial lapses in hygiene.[22] The school's water and sanitation systems were also compromised: the UV disinfection unit was non-functional, and residual chlorine levels were consistently below recommended standards.[23] In the absence of soap at handwashing stations, effective hand hygiene was not possible, increasing the likelihood that viral particles remained on the hands of an infected handler.[24] The practice of stacking trays while still wet further promoted cross-contamination, as moisture facilitates the persistence and transfer of enteric pathogens.[25] Collectively, these environmental deficiencies created conditions in which contamination introduced by a single infected food handler could spread widely, highlighting the need for reliable sanitation infrastructure alongside appropriate food-handler management.

Limitations

This investigation faced several limitations. Most cases were young children, which may have affected the accuracy of symptoms and food history reporting. To improve data quality, information was also obtained from parents and teachers. Recall bias was possible due to the retrospective nature of questionnaires, though data collection occurred promptly after the outbreak to minimize this issue. Detection of norovirus in a food handler occurred after illness onset, limiting confirmation of their role in transmission, but the epidemiological evidence and known potential for asymptomatic shedding support their involvement. Whole genome sequencing was not available to confirm genetic links between cases, although consistent clinical and laboratory findings suggest a common pathogen. Environmental samples were collected after cleaning, although before chlorination. Norovirus was not detected in water, or kitchen-surface samples, possibly because cleaning reduced its presence, although widespread coliform contamination still indicated poor environmental hygiene.

Recommendations

Teachers should reinforce proper student hygiene, particularly handwashing with soap, which was not available at the school's handwashing stations during the investigation. Kitchen practices should be improved by separating utensils for raw and cooked foods, ensuring trays are thoroughly washed and dried before reuse, and enforcing glove use when handling ready-to-eat items. Routine food-safety training and supervision should be coordinated by local health authorities in collaboration with the school administration, with the hospital providing technical support during outbreak response. The school should also repair and maintain its water treatment system, including restoring UV disinfection, performing regular reverse osmosis system maintenance, and maintaining residual chlorine at recommended levels.

Conclusion

A foodborne norovirus outbreak occurred at a school in Hua Taphan District, Amnat Charoen Province, Thailand, most likely caused by contaminated chicken rice, with subsequent secondary person-to-person transmission. Poor sanitation conditions may have further facilitated transmission. Recommendations focused on improving food-handling practices, strengthening hand hygiene infrastructure, and ensuring regular maintenance of the school's water treatment system to prevent future outbreaks.

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Author Contributions

Waritnun Anupat: Conceptualization, data curation, formal analysis, methodology, project administration, validation, visualization, writing—original draft, writing—review & editing. **Drunpob Srithammawong:** Conceptualization, data curation, validation. **Patchanee Plernprom:** Conceptualization, data curation, validation. **Pochana Choosang:** Conceptualization, data curation, validation. **Thanit Rattanathumsakul:** Methodology, supervision**. Chayanit Mahasing:** Methodology, resources, supervision, validation, writing—review & editing.

Ethical Approval

Since this study was a part of a routine public health outbreak investigation, ethics approval was not required.

Informed Consent

Not applicable. This study used fully de-identified secondary data obtained from routine outbreak surveillance and reporting systems. No identifiable personal information was collected or used, and the data cannot be linked back to individual participants.

Data Availability

The datasets used and/or analyzed in this study are available from the author on reasonable request (via anupatwritnun@gmail.com).

Conflicts of Interest

The authors declare no conflicts of interest.

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

During the preparation of this work, the authors used ChatGPT-5 (OpenAI) to enhance clarity and improve grammatical accuracy. The content generated by this tool was reviewed and edited by the authors, who take full responsibility for the final version of the manuscript.

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References

1. World Health Organization. Estimating the Burden of Foodborne Diseases [Internet]. Geneva: World Health Organization; 2024 [cited 2025 Apr 9]. <https://www.who.int/activities/estimating-the-burden-of-foodborne-diseases>
2. Winder N, Gohar S, Muthana M. Norovirus: An Overview of Virology and Preventative Measures. Viruses. 2022 Dec 16;14(12):2811. doi: 10.3390/v14122811.
3. Department of Disease Control, Ministry of Public Health. Report of surveillance of food poisoning in Thailand 2024 [Internet]. Nonthaburi: Department of Disease Control; 2024 [cited 2025 Jun 1]. <https://dds-eservice.moph.go.th/web-portal>
4. Udompat P, Srimuang K, Doungngern P, Thippamom N, Petcharat S, Rattanatumhi K, et al. An unusual diarrheal outbreak in the community in Eastern Thailand caused by Norovirus GII.3[P25]. Virol J. 2024 Jan 19;21(1):21. doi:10.1186/s12985-024-02296-z.
5. Pongsuwanna Y, Tacharoenmuang R, Prapanpoj M, Sakon N, Komoto S, Guntapong R, et al. Monthly distribution of norovirus and sapovirus causing viral gastroenteritis in Thailand. Jpn J Infect Dis. 2017;70(1):84–6. doi:10.7883/yoken.JJID.2015.440.
6. Zhang H, Gu XQ, Zhang LL, Wang CJ, Wei Z. Epidemiology of norovirus outbreaks in kindergartens, primary Schools, and junior high schools in Xian, China, from October 2020 to February 2023. Med Sci Monit. 2025 Nov 5;31:e949902. doi:10.12659/MSM.949902.
7. Wang J, Rui J, Zhu Y, Guo X, Abudunaibi B, Zhao B, et al. Evaluation of the transmissibility of norovirus and the effectiveness of prevention and control measures for schools in Jiangsu Province. Ann Med. 2023;55(2):2246474. doi:10.1080/07853890.2023.2246474.
8. Lyu H, Liang D, Luo R, Feng Y, Liu L, Yang S, et al. Improving knowledge, attitude and practice on norovirus infection diarrhea among staff of kindergartens and schools: a before-after study. BMC Public Health. 2024 Dec 1;24(1):1755. doi:10.1186/s12889-024-19235-w.
9. Fahim NK, Negida A. Sample size calculation guide-part 2: how to calculate the sample size for an independent cohort study. Adv J Emerg Med. 2018;3(1):e12. doi:10.22114/AJEM.v0i0.104s.

10. Phetsindechakul N, Arkaranupappong U, Chaiyanuwattiwong S, Sehawong P, Keawluanthong W. An outbreak investigation of Salmonella food poisoning in a primary school of Mueang district, Nakhon Sawan province, July 2020. Dis Control J [Internet]. 2022 [cited 2025 Nov 13];48(2):448–57. <https://he01.tci-thaijo.org/index.php/DCJ/article/view/249095>

11. Zou G. A modified Poisson regression approach to prospective studies with binary data. Am J Epidemiol. 2004 Apr 1;159(7):702–6. doi:10.1093/aje/kwh090.

12. Wickham H, Averick M, Bryan J, Chang W, McGowan L, François R, et al. Welcome to the Tidyverse. J Open Source Softw. 2019 Nov 21;4(43):1686. doi:10.21105/joss.01686.

13. Bureau of Food and Water Sanitation, Department of Health, Ministry of Public Health (TH). Food sanitation assessment form (SAN): school cafeteria (In accordance with the Ministerial Regulation on Sanitary Standards for Food Premises, 2018) [Internet]. Nonthaburi: Bureau of Food and Water Sanitation; 2022. 4 p. Thai.

14. Arvelo W, Hall AJ, Estevez A, Lopez B, Gregoricus N, Vinje J, et al. Diagnostic performance of rectal swab versus bulk stool specimens for the detection of rotavirus and norovirus: implications for outbreak investigations. J Clin Virol. 2013 Dec;58(4): 678–82. doi:10.1016/j.jcv.2013.09.019.

15. Hall AJ. Noroviruses: the perfect human pathogens? J Infect Dis. 2012 Jun;205(11): 1622–4. doi:10.1093/infdis/jis251.

16. Newman KL, Moe CL, Kirby AE, Flanders WD, Parkos CA, Leon JS. Norovirus in symptomatic and asymptomatic individuals: cytokines and viral shedding. Clin Exp Immunol. 2016 Jun;184(3):347–57. doi: 10.1111/cei.12772.

17. Wu QS, Xuan ZL, Liu JY, Zhao XT, Chen YF, Wang CX, et al. Norovirus shedding among symptomatic and asymptomatic employees in outbreak settings in Shanghai, China. BMC Infect Dis. 2019 Jul 8;19(1):592. doi:10.1186/s12879-019-4205-y.

18. Xue Y, Pan H, Hu J, Wu H, Li J, Xiao W, et al. Epidemiology of norovirus infections among diarrhea outpatients in a diarrhea surveillance system in Shanghai, China: a cross-sectional study. BMC Infect Dis. 2015 Apr 15;15:183. doi:10.1186/s12879-015-0922-z.

19. Tsang TK, Chen TM, Longini IM, Halloran ME, Wu Y, Yang Y. Transmissibility of norovirus in urban versus rural households in a large community outbreak in China. Epidemiology. 2018;29(5):675–83. doi:10.1097/EDE.0000000000000855.

20. Devasia T, Lopman B, Leon J, Handel A. Association of host, agent and environment characteristics and the duration of incubation and symptomatic periods of norovirus gastroenteritis. Epidemiol Infect. 2015 Aug 2; 143(11):2308–14. doi:10.1017/S0950268814003288.

21. Hardstaff JL, Clough HE, Lutje V, McIntyre KM, Harris JP, Garner P, et al. Foodborne and food-handler norovirus outbreaks: a systematic review. Foodborne Pathog Dis. 2018 Oct; 15(10):589-597. doi:10.1089/fpd.2018.2452.

22. Martin NH, Trmcic A, Hsieh TH, Boor KJ, Wiedmann M. The evolving role of coliforms as indicators of unhygienic processing conditions in dairy foods. Front Microbiol. 2016 Sep 30;7:1549. doi:10.3389/fmicb.2016.01549.

23. Kwio-Tamale JC, Onyutha C. Influence of physical and water quality parameters on residual chlorine decay in water distribution network. Heliyon. 2024 May 10;10(10):e30892. doi:10.1016/j.heliyon.2024.e30892.

24. Liu P, Yuen Y, Hsiao HM, Jaykus LA, Moe C. Effectiveness of liquid soap and hand sanitizer against Norwalk virus on contaminated hands. Appl Environ Microbiol. 2010 Jan;76(2):394–9. doi:10.1128/AEM.01729-09.

25. Samandoulgou I, Hammami R, Rayas RM, Fliss I, Jean J. Stability of secondary and tertiary structures of virus-like particles representing noroviruses: effects of pH, ionic strength, and temperature and implications for adhesion to surfaces. Appl Environ Microbiol. 2015;81(22):7680–6. doi:10.1128/AEM.01278-15.