Outbreak of acute norovirus gastroenteritis in a military facility in Singapore: a public health perspective

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INTRODUCTION Norovirus gastrointestinal disease (GID) outbreaks occur frequently in closed settings, with high attack rates. On October 16, 2008, a norovirus GID outbreak occurred at a Singapore military camp. This study describes the epidemiological investigations conducted to determine the cause of outbreak and the efficacy of the public health measures implemented.

METHODS Epidemiologic investigations included a case-control study of exposure to different food items and an environmental exposure survey. Stool samplings of patients and food handlers for common pathogens, and microbiologic testing of food and water samples were performed. Inspection of dining facilities and health screening of all food-handlers were also conducted.

RESULTS A total of 156 GID cases were reported on October 15–31, 2008. 24 (15.4%) personnel were positive for norovirus. The predominant symptoms were diarrhoea (76.3%) and abdominal pain (69.2%). There was no clinical correlation between any food item and the affected personnel. Testing of food and water samples, dining facility inspections and health screening of food handlers showed satisfactory results. The environmental exposure survey indicated possible transmission due to environmental contamination by vomitus in common areas. Comprehensive environmental decontamination was performed with hypochlorite solution, and personal hygiene measures were enforced. The outbreak lasted 17 days, with a decline in cases post intervention.

CONCLUSION Timely notification and prompt response can curtail disease transmission. Swift implementation of public health measures, such as emphasis on personal hygiene, isolation of affected cases and comprehensive disinfection of the environment, effectively stopped norovirus transmission and may be adapted for future GID outbreaks.

Keywords: diarrhoea, gastrointestinal disease, norovirus, outbreak, public health interventions
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INTRODUCTION

Acute gastroenteritis outbreaks are a public health concern throughout the world due to their frequent occurrence and attending morbidity. The incidence of gastroenteritis is estimated to be one in 1,000 worldwide,[1] with most cases occurring in areas of increased human congregation, such as military camps, hospitals and restaurants.[2-5] This results in absenteeism due to illness and disruptions due to interventions required to reduce the spread of the disease. Norovirus is a major cause of such outbreaks. Norovirus outbreaks frequently occur in institutional settings, with high attack rates owing to the persistence of these viruses in the environment, thus making containment efforts to reduce disease transmission difficult.[6-10]

Singapore has experienced large norovirus outbreaks in different settings. These include several outbreaks in schools, affecting hundreds of students and resulting in substantial absenteeism and disruption to school activities.[11-13] Another norovirus outbreak in a Singapore community hospital affected 79 patients and caused one death,[14] while an outbreak in a community from contaminated shellfish resulted in 305 cases.[15] On October 16, 2008, a norovirus gastroenteritis outbreak occurred at a military camp in Singapore. This paper describes the epidemiological investigations conducted to determine the cause and extent of the outbreak, as well as the efficacy of the public health measures implemented. The lessons learnt would assist policymakers and public health professionals to deal with similar outbreaks in the future.

METHODS

The Singapore Armed Forces (SAF) is a conscript military where all males enter after high school, at the age of 18–19 years. The SAF maintains primary healthcare facilities in its camps to provide primary healthcare to all its personnel. All healthcare consults are entered into an electronic medical records (EMR) system. Data from the system can be extracted and analysed in real-time, allowing for efficient monitoring for infectious disease outbreaks. The SAF adopts a series of infectious disease outbreak detection and prevention measures, which includes surveillance via the EMR and reports from the medical doctors on the ground. There is an investigation team on 24-hour standby to respond to any outbreaks within two hours of reporting.

For a gastrointestinal disease (GID) outbreak, the SAF criteria was adopted from the Ministry of Health Singapore

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criteria and is defined as the presence of ten or more cases of GID with onset within 24 hours, which are epidemiologically linked by time, place and likely exposure. A case of GID is defined as having at least three episodes of watery stools and/or two episodes of vomiting. The SAF GID outbreak investigation process consists of a comprehensive protocol of procedures. Upon suspicion of possible GID outbreak, the investigation team verifies the details and confirms the presence of an outbreak. Upon confirmation, the team visits the camp to conduct the investigation. This includes an inspection of all dining facilities and water supplies, and the relevant food and water samples are sent for microbiological testing. Any suspected food or water source implicated is shut down to prevent further spread. An epidemiological food survey of different food items served up to 48 hours preceding the outbreak is also conducted among the patients and controls. Finally, an activity and environmental exposure survey is conducted on laboratory-positive cases, concerning the places that they had visited in order to determine any possible common sources of infection.

The outbreak occurred in Camp A, a training camp where soldiers stayed in residential dormitories with common toilets on each floor level and two common dining facilities. On the morning of October 16, 2008, there was a report from Camp A that 14 soldiers had met the criteria for GID. The report was verified with the medical doctors on the ground and the EMR. An epidemiological investigation was conducted in order to ascertain the cause of the outbreak and to enforce preventive measures to curtail further disease spread. Information was promulgated throughout the camp to inform all affected personnel to report to the medical facility. There was close tracking of all GID cases reporting to the medical facility throughout the duration of the outbreak. At the onset, a case-control food survey was initiated to determine if any food sources were implicated as a possible cause of the outbreak, since these systemic sources could result in continuing infections. The cases included 12 of the initial 14 soldiers who met the criteria for GID (two were sent on home medical leave) and the controls who were randomly selected from asymptomatic soldiers from the same platoon as the affected soldiers. The survey included different food items served up to 48 hours preceding the outbreak. The laboratory-positive cases were also surveyed regarding their movements during the two days before their symptom onset, with particular attention to common areas and significant events such as exposure to other servicemen's body fluids.

An environmental inspection of the two dining facilities located within the camp was also conducted, with the focus on overall hygiene and detection of any lapses in food preparation. The medical fitness and vaccination schedules of the food handlers were evaluated. Early preventive measures, focusing on environmental and personal hygiene, were then instituted. These measures were part of the on-going health education provided to the servicemen and were emphasised as part of outbreak management. In accordance with the National Environmental Agency hygiene regulations,[16] microbiological tests were performed on the food samples (daily food servings were routinely collected and stored at 0°C–3°C for 48 hours). Tests were performed to measure the total plate count, total coliform count and the presence of *Escherichia coli*, *Staphylococcus aureus*, *Salmonella* spp., *Shigella* spp., *Vibrio cholerae*, *Vibrio parahaemolyticus*, *Clostridium perfringens*, *Listeria monocytogenes*, *Bacillus cereus* and *Campylobacter jejuni*. Water from various taps in the vicinity of the outbreak was collected by the Public Utilities Board, the national public water agency in Singapore, and tested for physical, chemical and bacteriological parameters. Finally, stool samples of the affected soldiers and food handlers were collected and tested for a panel of nine pathogens: Norovirus, *Salmonella* spp., *Shigella* spp., *Clostridium perfringens*, *Campylobacter jejuni*, *Vibrio parahaemolyticus*, *Vibrio cholerae*, *Listeria monocytogenes* and *Bacillus cereus*, using reverse transcriptase-polymerase chain reaction.

Table I. Clinical symptoms of GID cases (n = 156).

Symptom	Frequency (%)
Diarrhoea	119 (76.3)
Abdominal pain	108 (69.2)
Vomiting	40 (25.6)
Fever	34 (21.8)
Nausea	27 (17.3)

The symptoms of the cases and results of food survey were characterised using descriptive statistics. The results of the food survey were further evaluated with Fisher's exact tests for small sample sizes. A p-value < 0.05 was considered to be statistically significant. Data was analysed using the Statistical Package for the Social Sciences version 16.0 (SPSS Inc, Chicago, IL, USA).

RESULTS

A total of 156 personnel in Camp A reported GID symptoms from October 15–31, 2008, with an estimated attack rate of 10.4% (about 1,500 people were at risk). The two most common symptoms reported were diarrhoea (76.3%) and abdominal pain (69.2%) (Table I). The symptoms were generally mild, and all the affected soldiers were treated at the medical facility as outpatients and given medical leave. None of the patients required referral or admission to a hospital. A total of 30 food items consumed over the past 48 hours were included in the food survey. From the survey, none of the food items were found to have significantly increased consumption by the GID cases (Table II).

Stool samples were obtained from all 156 soldiers and all 67 food handlers. The samples from 24 (15.4%) soldiers were found to be positive for norovirus, including those of six of the initial 14 outbreak cases; they were negative for the other pathogens tested. The stool samples of the food handlers were

Table II. Food survey.

Date	Food item	No. (%)		Risk ratio	95% CI	p-value
		GID cases (n = 12)	Controls (n = 32)			
Oct 14	Fried bee hoon	0 (0)	20 (63)	0	-	< 0.01
	Bread slice	6 (50)	29 (91)	0.26	0.11, 0.61	< 0.01
	Mock fish cake	2 (17)	18 (57)	0.24	0.06, 0.97	0.04
	Minced chicken	4 (33)	29 (91)	0.17	0.06, 0.45	< 0.01
	Butter spread	0 (0)	6 (19)	0	-	0.17
	Chicken nugget	10 (83)	32 (100)	0.24	0.14, 0.41	0.07
	Chocolate cake	1 (8)	24 (75)	0.07	0.01, 0.49	< 0.01
	Garlic bun	1 (8)	18 (56)	0.12	0.02, 0.85	< 0.01
	Brownie	0 (0)	16 (50)	0	-	< 0.01
	Madeline cake	1 (8)	16 (50)	0.14	0.02, 1.02	0.02
	Coffee	0 (0)	16 (50)	0	-	< 0.01
	Ovaltine	0 (0)	16 (50)	0	-	< 0.01
Oct 15	Fried egg with onions	10 (83)	32 (100)	0.24	0.14, 0.41	0.07
	Apple	9 (75)	13 (41)	3	0.94, 9.62	0.09
	Chicken whole leg	10 (83)	32 (100)	0.24	0.14, 0.41	0.07
	Lory cabbage	7 (58)	29 (91)	0.31	0.13, 0.73	0.02
	Chicken rice and chilli	9 (75)	32 (100)	0.22	0.12, 0.39	0.02
	Red apple	1 (8)	15 (47)	0.16	0.02, 1.12	0.03
	Butter cake	0 (0)	24 (75)	0	-	< 0.01
	Cheese sandwich	2 (17)	24 (75)	0.14	0.03, 0.56	< 0.01
	Nut fruffle swiss roll	0 (0)	17 (53)	0	-	< 0.01
	Chicken char siew bun	2 (17)	16 (50)	0.29	0.07, 1.16	0.08
	Horlicks	2 (17)	16 (50)	0.29	0.07, 1.16	0.08
	Tea	0 (0)	16 (50)	0	-	< 0.01
Oct 16	Chicken patty	7 (58)	31 (97)	0.22	0.10, 0.47	< 0.01
	Boiled egg	6 (50)	28 (88)	0.29	0.12, 0.71	0.02
	Burger	7 (58)	30 (94)	0.26	0.12, 0.60	0.01
	Hot dog bun	3 (25)	27 (84)	0.16	0.05, 0.49	< 0.01
	Baked beans	4 (33)	27 (84)	0.21	0.08, 0.58	< 0.01
	Jam	0 (0)	7 (22)	0	-	0.16

Note: None of the food items were found to be significantly linked to the cases of GID. CI: confidence interval; GID: gastrointestinal disease

negative. Swabs to test for bacteria from the hands of the food handlers as well as the dining facility equipment were also negative and had unremarkable total coliform counts. Laboratory analysis of the food samples served up to 48 hours preceding the outbreak had negative cultures for the microbiological pathogens tested, with the exception of a slightly elevated total coliform counts for two food samples. However, these were deemed not contributory, as they did not correlate with exposures determined from the food survey. All water sampling analyses were physically and bacteriologically satisfactory.

The dining facilities were inspected and no major non-conformance was observed in terms of hygiene or operations. All equipment was checked and found to be in hygienic and working condition. The vocational fitness of the food handlers was also verified and found to be in order. The dining facilities were then cleared as a potential source of the outbreak and allowed to continue serving food. All 24 norovirus-positive soldiers were surveyed regarding their movements in the preceding 48 hours before the onset of their symptoms, with particular attention paid to movement in common areas and significant events. Of note, several norovirus-positive cases had incidences of possible exposure in various common areas such as the toilets in the residential areas, stadium and accommodations. This led to the initial suggestion that propagation of the GID cases could be due to direct exposure and environmental contamination.

Upon identification of a GID case, the soldier was isolated via home medical leave or kept under observation in the sick bay at the medical centre. Environmental hygiene measures were instituted on October 16, including washing and disinfecting of all toilets, water coolers and taps in the camp. All personnel and food handlers were reminded to wash their hands at mealtimes and after visiting the toilet, as well as to ensure that their nails were kept short and clean and that their personal equipment was also kept clean. Measures to prevent cross-contamination were also reinforced, including thorough cleaning of water containers and discouraging the sharing of personal items or food. Daily

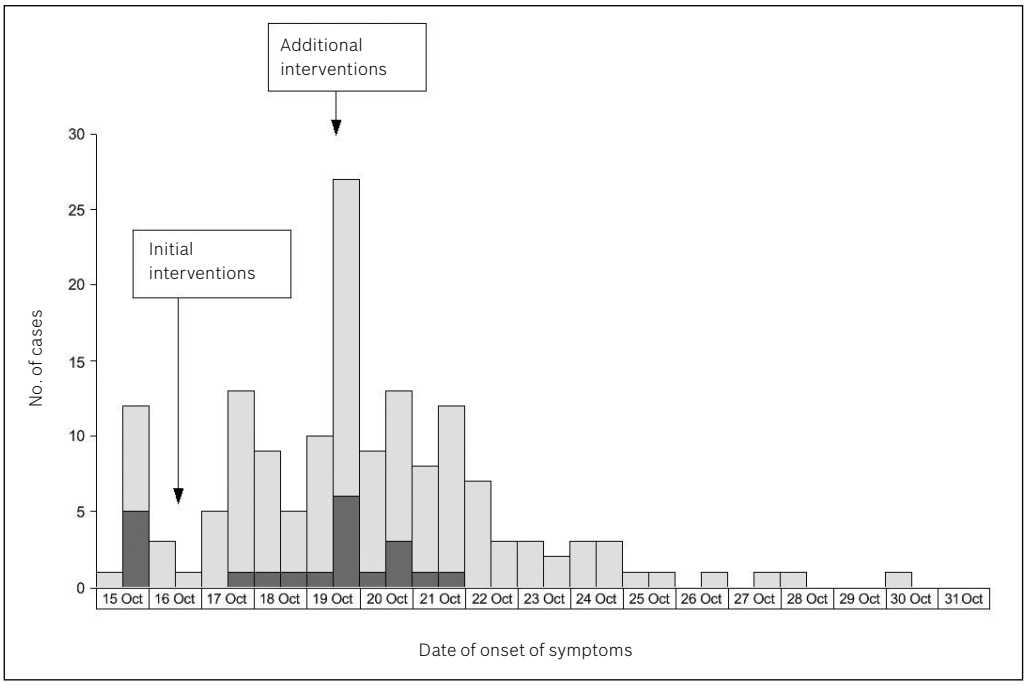

Fig. 1 Graph shows the outbreak pattern of gastrointestinal disease in the study. The left and right bars for each day correspond to *am* and *pm*, respectively.

sanitisation of the dining facilities and improved surveillance of food handlers were also conducted. On October 19, upon notification of the first norovirus-positive stool samples, additional measures were immediately mandated to ensure comprehensive decontamination due to the environmental persistence of norovirus. Hypochlorite solution was used to disinfect all common areas, including the cookhouses and living areas, especially if there was any spillage of potentially infected material.

From October 15 to October 19, a total of 88 cases with onset across these five days were reported. Upon implementation of the additional measures on October 19, the number of GID cases decreased substantially toward the baseline, with a total of 68 cases with onset within the next 12 days from October 20 to October 31 (Fig. 1). On October 31, the outbreak was declared to be over, having satisfied the criteria of at least two disease incubation periods where the number of personnel with GID returned to baseline and no further stool samples tested positive for norovirus.

DISCUSSION

GID outbreaks result in substantial morbidity and disruption to activities. As such, it is important to have systems in place to prevent outbreaks from occurring, including hygiene measures and clean food and water supply. However, even with the best of systems, outbreaks do occur and it is important to promptly identify[17] and control them. Our reporting system through the medical officers and syndromic surveillance[17] enabled us to detect the outbreak within 24 hours of onset of the first reported case. This requires a concerted effort to epidemiologically link different cases, and is easier to achieve in an institutional setting where the majority of cases seek healthcare at a common facility.

Microbiological studies suggested norovirus as the likely cause of this outbreak. Norovirus is a common cause of viral-induced GID outbreaks.[6-8,15] Its is usually transmitted by the faecal-oral route, and may spread through contact with contaminated surfaces and ingestion thereafter.[5-8] Norovirus can also be transmitted by direct person-to-person spread. Evidence exists for transmission due to aerosolisation of vomitus, resulting in droplets contaminating surfaces or entering the oral mucosa and subsequently being swallowed.[6-8,18] Norovirus infections usually present as acute onset nausea and vomiting, and watery, non-bloody diarrhoea with abdominal cramps.[1,2,15] In a norovirus outbreak among the United States (US) army trainees,[2] 67% had diarrhoea and 76% had abdominal pain, which were similar to our cases, although the US outbreak had more vomiting cases (80% vs. 26%). Vomiting is related to a virus-mediated change in gastric motility and delayed gastric emptying, and has been shown to be infectious;[6-8,18] it is a major factor in norovirus transmission and can double the attack rate.[19] In a school outbreak of norovirus, vomiting was found to be a significant factor in the transmission of infection,[18] while in another outbreak among food-service workers, vomitus was found to increase environmental contamination and transmission of virus.[19] In this case, the disease may have been propagated due to close contact with infected vomitus in common areas, as shown by our environmental exposure survey.

Norovirus gastroenteritis outbreaks are explosive, with high attack rates.[20,21] The highly contagious nature of the virus,[6-8] the short incubation period (12–48 hours)[5-8] and the close proximity of soldiers in the military setting resulted in rapid spread across the camp and a spike of 88 cases over five days, with the entire outbreak lasting 17 days. The overall attack rate of 10.4% is similar to that in other military settings where public health measures were enforced; an outbreak of norovirus had an attack rate of 12% over a period of one week among US army trainees[2] and

12.4% over five weeks in a German military base.[22] These attack rates are relatively low compared to outbreaks in other closed settings, e.g. two separate norovirus outbreaks in hospitals in New Zealand had an attack rate > 50% over a similar period of 14–16 days.[20] In Hungary, a surveillance of 85 norovirus outbreaks in hospitals showed an average attack rate of 32%, lasting 14 days on average.[21] Most outbreaks of norovirus gastroenteritis have been in closed settings like nursing homes, schools and resorts or cruise ships.[4] The lower attack rates in military camps may have been due to the substantial measures taken to attempt to reduce the spread and peak incidence of the disease.

Public health interventions during a GID outbreak include vigilant hygiene control among all personnel, particularly food handlers.[7,8,23,24] Frequent and thorough hand washing with soap has been found to be an effective means of hygiene control.[23,24] Wearing of masks with eye-protection should also be considered for persons who clean areas that are substantially contaminated by faeces or vomitus, and soiled linens and clothes should be handled as little as possible, with minimum agitation.[23,24] As environmental surfaces have been implicated in the transmission of enteric viruses, soiled surfaces should be cleaned with an appropriate germicidal product (e.g. household bleach).[23,24] Isolation of individuals with GID symptoms also reduces person-to-person transmission of the disease.[6-8,23,24] Based on our investigations, it was difficult to ascertain the origin for the GID outbreak in the first instance. However, at the onset, we swiftly introduced various general public health measures, including education and emphasis on personal hygiene measures, regular cleaning of common areas, increased surveillance and provision of home medical leave to patients in order to break the chain of transmission. This was followed by more definitive measures, such as thorough decontamination of all common areas with hypochlorite solution once the diagnosis of norovirus was determined, as it has been shown to persist in the environment.

In the US army camp outbreak, prompt closure of the dining facility and the use of temporary medical facilities for quarantine were shown to decrease secondary propagation.[2] The German military base outbreak was noted for the thorough preventive measures implemented, i.e. quarantine of sick personnel, disinfection of common areas, personal hygiene and cleaning of dining facilities.[22] Overall, prompt implementation of these public health measures was successful in curbing this outbreak, as seen in the rapid decline in cases post-intervention (Fig. 1). Strict enforcement of these measures is likely to be effective not only against norovirus outbreaks, but for all GID outbreaks in general.

The limitations of this study include the lack of typing studies on norovirus to link the cases through molecular epidemiology. Moreover, the environmental exposure survey was only performed for all norovirus-positive soldiers. This survey should have been extended to all GID cases and controls to conclusively determine the likely sources of infection. In addition, there was no distinction in the clinical presentation of norovirus-confirmed cases and that of the other GID cases. The measures implemented in this study were successful in a military setting, where co-ordinated efforts could be readily undertaken. For GID outbreaks in the community, it may be more difficult to identify the outbreak early and trace the source of infection. Consequently, the lack of early identification of an outbreak may result in inadequate preventive measures implemented and more extensive disease propagation; therefore, surveillance is highly important. Nevertheless, timely notification, coupled with prompt response can break the chain of disease transmission. This study has shown that swift implementation of public health measures, such as education and emphasis on personal hygiene, isolation of affected cases and comprehensive disinfection of the environment, can effectively curtail norovirus transmission and may thus be adopted for future GID outbreaks.

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