Original Article

An Outbreak of *Salmonella* Gastrointestinal Illness in a Military Camp

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Abstract

Introduction: Non-typhoidal *Salmonellae* are important causes of bacterial food-borne infection, especially in institutional settings. An outbreak of gastrointestinal infection occurred in a military camp in January 2007, and an epidemiological outbreak investigation was conducted. Materials and Methods: A survey was conducted on soldiers in the camp on their clinical symptoms, and recent meals consumed. After determining the affected meal, a subsequent survey was conducted on those who had eaten the meal. A case-control study was then performed to determine the outbreak's likely food source. Laboratory tests were also conducted to determine the bacteriological cause. Results: Of the 94 responders, 55 (58.5%) met our case definition of gastrointestinal illness. The dinner on 9 January was the most likely affected meal, with the onset of symptoms occurring within 6 to 36 hours. The mashed potato was the most likely food source with an attack rate of 80.7% for those who consumed it versus 32.7% for those who did not (*P* <0.01). From the multivariate analysis, the mashed potato remained the only food item independently and significantly associated with infection, with a relative risk of infection 9.49 times those who did not consume it (95% CI, 2.73-32.97). *Salmonella* group E was cultured from 4 individuals. Although no specific contamination was identified, the mashed potato was stored for more than 5 hours before the last serving. Conclusion: Risk during preparation of large quantities of food should be identified a priori, and measures taken to reduce them, to prevent outbreaks.

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Key words: Case-control study, Epidemiological investigation

Introduction

Bacterial food-borne infections are common, especially where hygiene has not been optimal. Non-typhoidal Salmonellae are important causes of bacterial food borne infection worldwide. There are an estimated 1.4 million cases of *Salmonella* infections annually in the United States,[1,2] while non-typhoidal *Salmonellae* has been found to be responsible for 56.1% of acute admissions for diarrhoea among children in one hospital in Thailand.[3] In Singapore, 345 and 296 cases of non-typhoidal laboratory confirmed salmonellosis were reported in 2004 and 2005 respectively.[4]

Consumption of contaminated eggs and poultry meat are common sources of human salmonellosis, and a wide range of domestic and wild animals, including poultry and swine, can act as reservoirs for *Salmonella*.[5] Food-borne outbreaks of *Salmonella* have often been reported in institutional settings such as schools and nursing homes,[6] and have been shown to be explosive in nature.[7]

An outbreak of non-typhoidal *Salmonella* gastrointestinal infection occurred in a Singapore Armed Forces (SAF) camp in January 2007. The SAF has personnel residing across several military camps, and the cookhouses within these camps prepare and provide meals for all personnel within the camp facility. In one of these camps (an overseas Camp A), a celebratory dinner was held on 9 January 2007 to usher in the New Year. That evening, an outbreak of gastrointestinal illness began and lasted for 2 days, affecting a total of 55 soldiers. We describe the epidemiological investigation of the outbreak, and how the likely source of infection was determined.

Materials and Methods

After the outbreak was declared in Camp A on 10 January 2007, all soldiers who sought medical consult for gastrointestinal symptoms were ordered to report to the camp's medical facility for assessment and follow-up. An epidemiologic curve was drawn based on the onset of symptoms as reported by those who reported to the medical

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facility. An initial survey was also conducted within 3 days of the declaration of the outbreak on all the soldiers in the camp. The survey included the presence of clinical symptoms, and the source of their meals consumed in the 3 days leading up to the onset of the outbreak. For the purposes of this epidemiological investigation, we determined the case definition of gastrointestinal illness for this outbreak to include nausea, vomiting, diarrhoea, or abdominal pain; with or without fever. Analysis was first performed to determine the likely affected meal. From the initial results, a subsequent survey was conducted on all soldiers who had eaten at the affected meal to determine the consumption of the various food items served. A case-control study was then performed to determine the likely food source of the outbreak.

Laboratory tests were conducted on the camp's water supply to exclude it as a possible source of infection, and stool samples were collected from 31 symptomatic soldiers (all except one of the soldiers who presented to the camp's medical facility, for the one soldier could not produce any sample) and 15 food handlers for bacteriological tests. From the results of the survey and laboratory tests, further investigation into the food preparation process was conducted to determine the cause of the outbreak. This included interviews with food handlers and inspection of the camp premises.

Statistical Methods

For the descriptive analysis, attack rates for the various meals and food items were calculated to determine the food item that most likely caused the outbreak. chi-square and Fisher's exact tests were used to compare the categorical outcomes for statistical significance. Logistic regression models were then used to explore exposure factors associated with the development of disease. Univariate analysis was performed using all relevant input variables as covariates. For the multivariate analysis, we included all input variables to to determine the significant variables while adjusting for all possible confounders.

All statistical analyses were performed using Stata 9.0 (Stata Corp, College Station, TX, 2005). All tests were conducted at the 5% level of significance, and the relative risk (RR) and corresponding 95% confidence intervals (CI) reported were applicable.

Results

A total of 106 soldiers were stationed in Camp A during the period of the outbreak. Out of these 106 soldiers, 94 were present post-outbreak and answered the questionnaire (response rate of 88.7%). The non-responders had left the Camp for overseas after the outbreak and could not be promptly contacted for the epidemiological investigation.

Table 1. Selected Symptoms Among the Soldiers in Camp A (n = 94)

Symptom	**Number affected**	**%**
Nausea	26	27.7
Vomiting	47	50.0
Diarrhoea	53	56.4
Abdominal pain/colic	16	17.0
Fever	40	42.6

Table 2. Tabulation of Those Who Ate at the Celebratory Dinner on 9 January and Those Who Were Identified As Cases in the Outbreak

		Ate at 9 January celebratory dinner		
		Yes	No	Total
Case	Yes	55	0	55
	No	30	9	39
	Total	85	9	94

P <0.01

Table 1 shows selected symptoms among the 94 responders, of which 55 met our case definition of gastrointestinal illness. Of those who had symptoms, only 32 soldiers sought treatment at the camp's medical facility, and all of the cases were mild and recovered with symptomatic or intravenous fluid therapy.

The celebratory dinner on 9 January was determined to be the most likely meal that caused the outbreak. As shown in Table 2, all soldiers who did not eat at the dinner on 9 January were well, while all the cases ate at the dinner. From the epidemic curve of those who sought treatment (Fig. 1), the onset of symptoms all occurred within 6 to 36 hours of the affected meal, with the majority occurring 12 to 24 hours post-exposure.

Table 3 shows the individual food items that were consumed by the 85 soldiers who ate at the celebratory

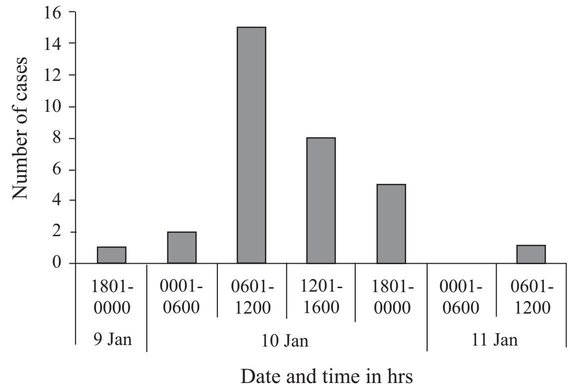

Fig. 1. Epidemic curve of the gastrointestinal disease outbreak in Camp A

Table 3. Analysis of the Food-specific Attack Rates for Various Different Food Items Consumed during the Dinner on 9 January 2007 (n = 85)

	Ate the specific food			Did not eat			Risk ratio	*P* value
	Ill	Total	Attack rate	Ill	Total	Attack rate		
Baked bun	16	23	69.6%	39	62	62.9%	1.11	0.57
Butter rice	29	42	69.0%	26	43	60.5%	1.14	0.41
Macaroni	45	66	68.2%	10	19	52.6%	1.30	0.21
Roast chicken	38	56	67.9%	17	29	58.6%	1.16	0.40
Lamb chop	44	64	68.8%	11	21	52.4%	1.31	0.17
Lemon fish	39	56	69.6%	16	29	55.2%	1.26	0.19
Mashed potato	46	57	80.7%	9	28	32.1%	2.51	<0.01
Salad	22	30	73.3%	33	55	60.0%	1.22	0.22
Thousand island dressing for salad	25	33	75.8%	30	52	57.7%	1.31	0.09
Honeydew	30	44	68.2%	25	41	61.0%	1.12	0.49
Rock melon	32	44	72.7%	23	41	56.1%	1.30	0.11
Water melon	32	48	66.7%	23	37	62.2%	1.07	0.67
Strawberry	32	46	69.6%	23	39	59.0%	1.18	0.31
Ice-cream	43	66	65.2%	12	19	63.2%	1.03	0.87
Coffee	49	74	66.2%	6	11	54.5%	1.21	0.45
Tea	46	71	64.8%	9	14	64.3%	1.01	0.97
Fruit punch	49	76	64.5%	6	9	66.7%	0.97	0.90

dinner on 9 January. From the attack rates, the mashed potato was the most likely food source of the outbreak with an attack rate of 80.7% for those who consumed the food versus 32.7% for those who did not consume it (P <0.01). It was the only food source with a significant risk ratio. From the univariate analysis, those who ate the mashed potato had a relative risk of acquiring infection 8.83 times those who did not consume the mashed potato (95% CI, 3.15-24.74). From the multivariate analysis, the mashed potato remained the only food item that was independently and significantly associated with acquiring gastrointestinal symptoms. Those who consumed mashed potato had a relative risk of acquiring infection 9.49 times those who did not consume it (95% CI, 2.73-32.97).

From the laboratory tests, stools samples from 4 individuals cultured *Salmonella* group E. None of the dedicated food preparers had any positive stool cultures, although most other soldiers also assisted in setting-up the event. Tests of water from different sources did not yield any potentially infective agents. An investigation of the kitchen that prepared the food within the camp found it clean and in good condition. All the dedicated food preparers and handlers had the relevant vaccinations, wore disposable gloves during food preparation, and none reported any illness during the food preparation, which occurred solely on 9 January. Unfortunately, no samples of the food were kept after the event and tests could not be performed on the food items.

Further investigation into the preparation of the mashed potato found that the potatoes were first boiled on the morning of 9 January, and were then peeled by hand and placed in a large metal container. Butter, UHT milk and bay leaves were then added to the potatoes, and the mixture was mashed with a large manual hand-cranked masher. There were no samples of the butter available for verification, but milk from a similar batch was found to be within the expiry date. The masher was rarely used and the food handlers could not recall the last date of use, although it was found to be in good condition after the outbreak. The transport and serving of the mashed potatoes was in heated metal trays, but the time from cooking the various individual components of the mashed potato to the last serving was more than 5 hours.

Limitations of the paper include the lack of molecular analyses and typing of the *Salmonella* samples which would have conclusively shown that these soldiers had a common infection. In addition, samples should have been taken from all the soldiers regardless of illness symptoms. Neither was possible due to equipment, laboratory and cost constraints.

Discussion

The data implicated the mashed potatoes from the dinner of 9 January as the likely source of the outbreak, and *Salmonella* group E as the likely pathogen responsible. However, as no samples of food served at the dinner were available for microbiological analysis, there was no direct evidence of *Salmonella* contamination of the mashed potatoes.

The onset time of between 6 to 36 hours after the affected meal in this outbreak is consistent with reported incubation periods of 6 to 48 hours for *Salmonella* gastroenteritis.[5] The relatively large number of febrile cases of gastroenteritis (75.5%) is consistent with other reported outbreaks of *Salmonella* gastroenteritis.[7,8] As shown by the large number of affected soldiers, food-borne outbreaks can result in widespread morbidity and staff absenteeism; and therefore should be prevented to reduce the severe and abrupt impact.

In this case, the kitchen was found to be clean and none of the food handlers had reported any illness during food preparation. However, kitchen appliances, if used infrequently and inappropriately stored, may have been a potential source of contamination. Components of the mashed potato, such as the butter that was added may have also been a source of contamination, as dairy products have often been implicated as sources in outbreaks of *Salmonella* gastroenteritis.[9] The long interval between the boiling of the mashed potatoes and the time dinner was served made it possible for contamination and bacterial multiplication in the intervening period.

The United States Centres for Disease Control and Prevention (US CDC) recommends that food with the potential for *Salmonella* contamination (for example, shell eggs that are commonly contaminated with *Salmonella* via transovarial spread) should not be held in the temperature range of 4.6°C to 60°C for more than 2 hours, in order to prevent bacterial multiplication.[10] Cooking to an internal temperature of 60°C to 73°C is recommended by the US Food Safety and Inspection Service for destroying *Salmonella*.[11] The mashed potatoes were left at room temperature for several hours after preparation, which would have allowed for the multiplication of S*almonella* species. Serving and transport of food in heated metal trays may not have been sufficient to inactivate the bacteria, especially at the core of the mashed potato dish. The total time from cooking the last component of the mashed potato dish to the last consumption was more than 5 hours, and would have presented the opportunity for the multiplication of *Salmonella* in-situ. Proper reheating of the food to a core temperature of at least 70°C is necessary in such an instance.

Although the primary cause of salmonellosis is the consumption of contaminated foods, there is the potential for secondary spread, from person-to-person and also to other foods. *Salmonellae* are able to survive for several days in the environment,[12] and have been noted to survive for up to 4 weeks in contaminated toilets despite the use of cleaning fluids.[13] In addition, the median duration of faecal shedding of non-typhoidal *Salmonellae* after intestinal infection is approximately 1 month in adults and 7 weeks in children <5 years of age.[14] Secondary spread in this outbreak was controlled by strict enforcement of a high standard of personal, food and environmental hygiene among the food handlers and camp personnel. No further outbreaks of *Salmonella* occurred in Camp A as a result.

There are some limitations to this study, as the aim of the investigation was to identify possible sources of infection, to exclude any recurring sources, and to prevent future infections. It would have been ideal to conduct further typing studies on the *Salmonella* that was cultured from the patients, and to link the cases through molecular epidemiology. However, appropriate facilities were not available in the setting where Camp A was located. In addition, food samples were not available for testing because none were kept. This would have provided conclusive evidence as to the food source of the outbreak, and we recommend that food samples be stored after mass gatherings for potential screening. However, the control measures post-outbreak remained similar and would not be substantially influenced by the food source.

In the preparation of food for large gatherings, care should be taken in the food preparation phase involving proper handling of food but also food handlers, clean workspaces and equipment, and uncontaminated food products. In addition, food should not be prepared too long before consumption as many gastrointestinal diseases can reproduce substantially over a few hours at the right temperatures. If a lag time between preparation and consumption is unavoidable, proper storage and reheating of the food is necessary. In addition, food samples should be collected and stored if possible, even in one-off events, to determine possible sources of outbreaks.

Conclusion

Preparation of food in large quantities entails a risk of food contamination. This is especially so if large numbers of ingredients are mixed in multiple steps, and the food is kept for a long period after cooking before being served. The use of pre-packaged mixes in this case may have prevented food contamination by reducing the number of ingredients and steps required. Food preparation must take into account potential sources of infection, and systematically address them through proper preventive measures to reduce the frequency of outbreaks.

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Conflicts of interest statement: The authors declare that we do not have any conflicts of interest, financial or otherwise, in the study.

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