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Waterborne outbreak of gastroenteritis in a religious summer camp in Norway, 2002

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SUMMARY

In July 2002 an outbreak of acute gastroenteritis occurred in a camp facility in western Norway during a 10-day seminar, with around 300 guests staying overnight and several day-time visitors. Environmental and epidemiological investigations were conducted to identify and eliminate the source of the outbreak, prevent further transmission and describe the impact of the outbreak. Of 205 respondents, 134 reported illness (attack rate, 65%). Multivariate analysis showed drinking water and taking showers at the camp-site to be significant risk factors. Secondary person-to-person spread among visitors or outside of the camp was found. Norovirus was identified in 8 out of the 10 stool samples analysed. Indicators of faecal contamination were found in samples from the private untreated water supply, but norovirus could not be identified. This outbreak investigation illustrates the importance of norovirus as a cause of waterborne illness and the additional exacerbation through person-to-person transmission in closed settings. Since aerosol transmission through showering contributed to the spread, intensified hygienic procedures such as isolation of cases and boiling of water may not be sufficient to terminate outbreaks with norovirus.

INTRODUCTION

Viral pathogens are the most common cause of gastroenteritis in industrialized countries. A recent study on viral gastroenteritis in Europe showed that in several countries >95% of all non-bacterial outbreaks of gastroenteritis were attributed to norovirus [1]. Although person-to-person transmission is likely to be the main mode of transmission, especially in institutional settings, foodborne transmission has been reported to cause from 10% to over 50% of all norovirus outbreaks in different countries [2–4]. Food- and waterborne outbreaks are of particular concern due to the large number of people affected, and the potential for international involvement through global trade of food products. A report on waterborne outbreaks in the Nordic countries between 1975 and 1991 found norovirus to be the second most common cause of waterborne outbreaks after campylobacter [5]. However, in 60% of the outbreaks the causative agent was never reported. Diagnostic tools for the identification of some viral pathogens were not readily available at the time of these outbreaks, and it is probable that some of them were

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caused by norovirus. During the last 10 years there have been several programmes for upgrading the water supplies in Norway, but some waterworks still supply water of unsatisfactory quality. In 2001, 15% of the registered waterworks in Norway delivered water without any treatment or disinfection before distribution. These waterworks are generally small, supplying only 2% of the population [6]. However, during the holiday season they may also supply visitors and people staying in resorts or summer houses.

In July 2002 an outbreak of gastroenteritis occurred in a private holiday and conference centre in Western Norway. An environmental and epidemiological investigation was conducted in order to determine the source and mode of transmission, and to estimate the impact of the outbreak.

METHODS

Description of the outbreak

The centre was built in the 1970s and consisted of a main building, a chapel and five cottages. There was also a house for the janitor and his family who lived permanently on the site. Each of the cottages and the main building had a small kitchen, toilets and shower facilities. In total, there were 117 beds for overnight visitors. Additionally, visitors who arrived and slept in private boats used the centre's facilities. The main building had a large kitchen and a food hall where breakfast, lunch and dinner were served. The water was supplied from a drilled well located between the buildings and the seafront (Fig. 1). No water treatment occurred before distribution. The centre organized between 5 and 10 camps every year, and was also rented out for different, smaller events during weekends.

On 17 July, the local food control authority was informed that four of the visitors had vomited, and had experienced diarrhoea and stomach pain lasting approximately 1 day. The centre was at the time hosting a religious summer camp lasting from 12 to 21 July. There were approximately 250–300 overnight participants at the camp, several of whom did not stay for the whole 10-day period. Additionally there were many 1-day attendees.

Epidemiological investigation

We mailed questionnaires to all families entered in the booking list of the organizers of the camp. It was not possible to reach all participants since several persons arriving by boat or visiting only during the daytime were not registered. In total, 54 families were included, and asked about place and duration of stay, clinical symptoms, water and food consumed and about hygienic routines.

A case was defined as a person who visited the centre during the period 12–21 July 2002 and fell ill with vomiting or diarrhoea (defined as three or more loose stools during a 24-h period) within 3 days of the visit.

Univariate analysis and examination for a dose–response relationship for daily water intake was done by using Epi-Info, version 6.04 (CDC, Atlanta, GA, USA). Significant risk factors were included in a multivariate generalized linear model (binomial regression model) using STATA 8.0 (Stata Corporation, College Station, TX, USA). The significance level for exclusion of a variable from the model was set to 0·05. A variable for time of stay was also included in the model (present or absent after 16 July). We suspected a high degree of person-to-person transmission within families, so a second model was also investigated, where only index cases in each family (defined as all cases in each family occurring within 12 h of the first case in the family) were counted as cases. With this restricted case-definition, all remaining persons in the family, both symptomatic – if falling ill more than 12 h after the first case – and asymptomatic, were kept in the analysis as non-cases. Risk ratios (RR) from the multivariate model were used to calculate the population attributable risk per cent (PAF), defined as the proportion of the cases in the entire population presumably attributable to the exposure:

$$PAF = Pc(RR - 1)/RR,$$

where Pc = proportion of cases exposed [7].

Laboratory investigation

Eleven stool specimens were obtained from cases: two from members of the staff and nine from visiting guests. Stool samples were cultured for bacterial enteropathogens (including *Salmonella* sp., *Shigella* sp., *Campylobacter* sp., and *Yersinia* sp.). Ten samples were submitted for viral analysis, including norovirus.

Water samples were collected on 21 July and 13 August. The first samples were examined for total coliforms, thermostable coliforms and faecal streptococci.

A–D Guest houses
E Main building with kitchen
F Janitor's house
H Well (marked with circle)
I Septic tank (marked with circle)
Black square Chapel
---------- Water and sewer pipes

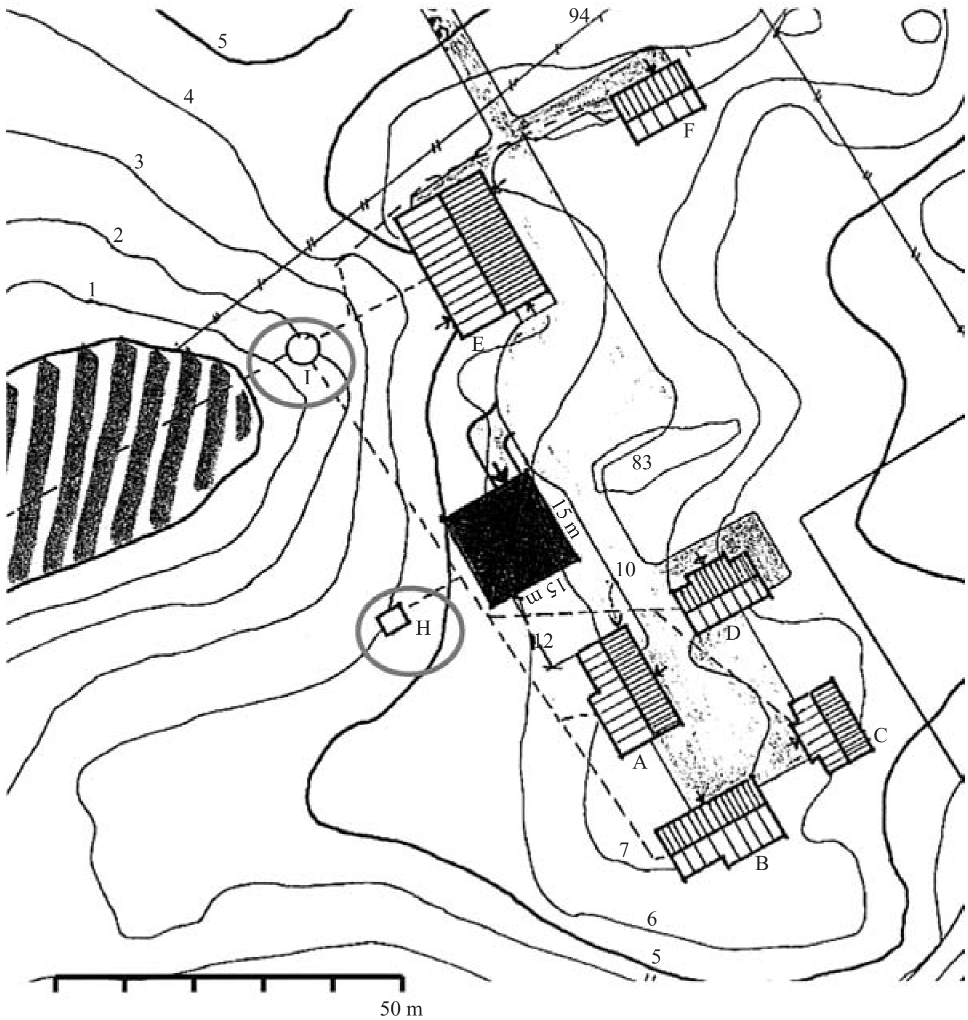

Fig. 1. Map of the centre's facilities.

Samples obtained on 13 August were also submitted to the Norwegian School of Veterinary Science for examination for norovirus.

Environmental investigation

The food control authority conducted the first inspection on the facilities on 18 July. The main house and kitchen were inspected, hygienic routines for kitchen staff scrutinized, and water samples sent for analysis. A further visit was made on 21 July. On 13 August, a full inspection of all facilities and the water supply was made in collaboration with the Norwegian Institute of Public Health.

RESULTS

Epidemiological investigation

The first persons fell ill on 15 July, and altogether 134 of 205 respondents reported having had gastrointestinal illness (attack rate, 65%). Only one person reported having had gastrointestinal illness during the 2-week period before arriving at the centre. The

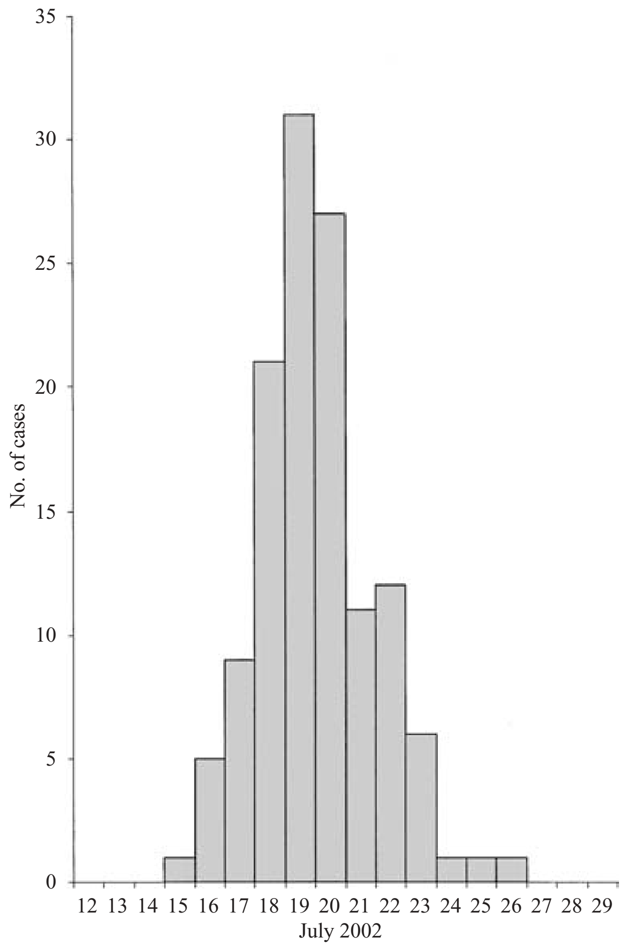

Fig. 2. Cases of gastroenteritis among visitors and residents at the summer camp in Norway by date of symptom onset, 12–26 July 2002.

outbreak peaked during the second week of the summer camp, and 79 (59 %) persons fell ill between 18 and 20 July (Fig. 2). Fifty-five persons (41 %) fell ill after leaving the centre.

There were no significant differences in attack rates between males and females or between children and adults. Vomiting was reported by 81 % and diarrhoea by 66 % (Table 1). The median duration of illness was 2 days (range 1–14 days). Eight persons (6 %) contacted a physician regarding their illness, and three were hospitalized. Of the adult cases (>16 years) nine of the 61 answering the questionnaire (15 %) had to stay home from work for a period of time, with a median of 3 days (range 1–7 days).

Two persons reported having had contact with persons with symptoms of gastrointestinal illness before arriving at the centre. Sixty-four persons reported knowing people that had not been at the summer camp, but had fallen ill after contact with someone returning from the camp. Two children participated in a large sporting event abroad a few days after leaving the camp, and developed symptoms there.

Table 1. *Clinical symptoms and treatment reported by visitors and residents at a summer camp in Norway, July 2002*

	No.	Total	%
Symptoms			
Nausea	113	128	88
Vomiting	108	133	81
Diarrhoea	86	131	66
Stomach pain	74	120	62
Head ache	51	122	42
Fever	31	92	34
Treatment			
Medication	17	131	13
Absent from work*	9	61	15
Contacted physician	8	134	6
Hospitalized	3	134	2

* Only adult cases (>16 years) included.

Univariate analysis of risk factors showed that drinking water and taking showers at the centre, eating shellfish, strawberries and unpeeled fruits were significantly associated with illness. Bringing one's own drinking water to the camp was negatively associated with illness (Table 2). Risk of illness increased with the daily amount of water consumed (χ^2 for trend 16·8, $P<0{\cdot}001$) (Table 3). Self-reported washing of hands before meals did not show any association with illness. In total, 78 (39 %) said they washed their hands before meals, 57 (28 %) said they did not, and 67 (33 %) reported that sometimes they did and sometimes they did not, or that they could not remember.

In multivariate analysis, only drinking the water and using the showers at the centre remained in the final model, with relative risks of 1·8 (95 % CI 1·1–2·8) and 1·5 (95 % CI 1·2–1·9) respectively. Seven of the 11 cases that had not drunk any water from the water supply reported that they had taken showers at the centre. Using these figures to calculate the population attributable fraction (PAF), we calculated that approximately 41 % of the cases could presumably be attributed to drinking water, and 23 % to using the showers at the centre. When only index cases in each family were counted as cases in the multivariate analysis, the association became stronger, with relative risks of 4·5 for drinking water and 1·7 for using the showers at the centre (Table 4), giving an

Table 2. *Attack rates (AR) and relative risks (RR), univariate analysis at a summer camp in Norway, July 2002*

	Exposed			Unexposed				
Exposures†	Ill	Total	AR (%)	Ill	Total	AR (%)	RR	95% CI
Sleeping in boat	85	133	64	49	72	68	0·94	0·77–1·15
Brought own water	78	134	58	54	68	79	0·73*	0·61–0·88
Drinking water from the centre	123	172	72	11	32	34	2·08*	1·28–3·39
Participated in common meal	101	145	70	33	60	55	1·27	0·98–1·63
Eating unpeeled fruits	25	32	78	65	112	58	1·34*	1·06–1·71
Eating mussel or shellfish	76	102	75	57	101	56	1·32*	1·07–1·62
Eating strawberries	58	74	78	52	99	53	1·49*	1·19–1·86
Washed hands before meals	51	78	65	82	124	66	0·99	0·81–1·21
Used toilets at the centre	123	177	69	10	25	40	1·74*	1·06–2·84
Used showers at the centre	92	116	79	41	87	47	1·68*	1·32–2·14
Swimming in the sea by the centre	106	159	67	27	44	61	1·09	0·84–1·41

* Significant at P level of 0·05.
† Of the food items, only those that were significant are presented.
CI, Confidence interval.

Table 3. *Attack rates (AR) and relative risks (RR) according to amount of water consumed per day at a summer camp in Norway, July 2002*

Water intake	Ill	Total	AR (%)	RR	95% CI
0 glass	14	37	38	ref.	—
1 glass	32	51	63	1·7	1·0–2·6
2–3 glasses	62	85	73	1·9	1·3–3·0
4–5 glasses	20	26	77	2·0	1·3–3·2
>5 glasses	5	5	100	2·8	1·8–4·2

CI, Confidence interval.

Table 4. *Multivariate analysis of risk factors for gastroenteritis at a summer camp in Norway, July 2002*

	Relative risk	95% CI
All cases (134 cases)		
Drinking water from the centre	1·8	1·1–2·8
Used showers at the centre	1·5	1·2–1·9
Index cases (78 cases)		
Drinking water from the centre	4·0	1·4–12
Used showers at the centre	1·7	1·1–2·5

CI, Confidence interval.

attributable fraction of the index cases of 69 and 28% respectively.

Laboratory investigation

Of the 11 faecal samples analysed, *Campylobacter* spp. were isolated from two samples, rotavirus from two and adenovirus from one. Norovirus was found in 8 out of 10 samples analysed.

From water samples obtained from the kitchen, meeting hall and one of the cottages on 21 July, coliforms (27, 45 and 23/100 ml respectively), thermostable coliforms (11, 13 and 9/100 ml) and faecal streptococci (1, 0 and 0/100 ml) were detected, indicating faecal contamination. The samples obtained directly from the well on 13 August had low numbers of coliforms (mean of 3/100 ml), faecal streptococci (mean of 3/100 ml) and were negative for thermostable coliforms and for norovirus.

Environmental investigation

The kitchen facilities were clean and well maintained, but the maximum water temperature was not adequate for dishwashing. The staff had double duties, so that the same people who prepared the food also cleaned bathrooms and living rooms.

The well for the water supply was located close to the main building (10–20 m from the nearest building; see Fig. 1). The well was about 80 m deep, and drilled at a slight angle towards the buildings. The ground was composed of rock, with limited coverage in the area. The water pipelines were located in the same trench as the sewage pipes. Sewage was collected in a two-chamber septic tank located 50 m from the well. The septic tank was emptied approximately twice a year. Leakage and breaks had previously been observed around the tank. The effluent from the septic tank was discharged through a pipeline out into the sea. Some blockage of the sewage was suspected, as 'bubbling' occurred when the toilets were flushed. There had been no maintenance of the water supply or sewage system since the facilities were built in the 1970s. When the chapel was built some years ago there had been some construction work involving blasting in the ground. The chapel is located 15–20 m above the well (Fig. 1).

Control measures

General hygiene advice was given during the first telephone call on 17 July. During the first visit more specific hygiene advice was given and boiling of drinking water was recommended. On the next visit it was clear that the previous advice had not been followed. Some of the kitchen staff who had been ill were transferred to other tasks. We strongly advised that people working in the kitchen should not participate in the cleaning of toilets and bathrooms. We also recommended an increase in the frequency of washing and disinfection of toilets, washes, and doorknobs to several times a day. Only bottled water or boiled water should be used for drinking purposes.

The summer camp ended on 21 July. The water supply was closed on 24 July, and all later bookings were cancelled until a safe supply could be provided. We recommended finding a new water source located further away from the centre. In an interim period, installation of a disinfection system to the already existing water supply was accepted for smaller events.

DISCUSSION

The source of this outbreak was faecally contaminated drinking water. Although norovirus could not be identified in the water samples, presence of faecal indicator bacteria and results from the epidemiological investigation both strongly indicated that contamination of the water supply was the initiating source, which was then further exacerbated by person-to-person transmission. Sampling of water for norovirus analysis was carried out 3–4 weeks after the outbreak, which may have led to the negative results. Visitors who had drunk tap water from the centre or taken showers at the centre had a significantly increased risk of gastroenteritis, and the risk increased with increasing water intake. Several hundred visitors during a short time placed a high demand on the water supply and the sewage system. During the camp there was very little rain. This may have caused a lowering of the ground-water level and thereby a high risk of contamination from the surface or from the leaking sewage collection system. Ground-water wells drilled in rock with little surface coverage are vulnerable to accidental contamination through cracks in the ground. As more and more people fell ill, increasing contamination of the water supply and person-to-person transmission could have contributed to the escalation of the outbreak.

The combination of continuous source and secondary person-to-person transmission made it more difficult to analyse the epidemiological data regarding risk factors and routes of transmission. Two co-existing routes of transmission complicated the estimation of associations with risk factors and attributable fractions. Independence between the outcome events is in general a prerequisite for normal epidemiological analyses and for standard regression models. We tried to compensate for this by using only the index cases in each family in the second model. However, this may still have biased our results. We are in the process of developing new statistical models that address these methodological challenges and further analyses will be conducted where dependency among the outcomes is taken into account.

Of the 11 persons tested, two cases of campylobacteriosis and two cases of rotaviral infection were also identified in this outbreak. These could be coincidental cases, but at least for campylobacter, transmission through contaminated water is also possible. Campylobacter is the most commonly identified cause of waterborne outbreaks in Norway, and consumption of untreated drinking water has also been identified as a risk factor for sporadic cases [8].

Waterborne outbreaks of norovirus in Norway have previously been described [9]. However, the present outbreak raises some new issues. A significant risk was associated with taking showers. This may be explained by swallowing water during showering, by transmission through aerosols or by contamination of hands following hand-to-mouth transmission. Standard recommendations to prevent illness during waterborne outbreaks are to boil water for food and drinking purposes and to enforce hygiene precautions to prevent person-to-person transmission. Our results show that this may not be sufficient to terminate outbreaks caused by norovirus. Although the association with showering was weak, the effect of using non-potable contaminated water on gastroenteritis needs to be investigated further.

The water regulations in Norway require two hygienic barriers for water supplies serving more than 20 households. However, the requirements for smaller private supplies are less strict. This outbreak shows that inadequacies in private supplies can also have significant consequences. If one estimates 400 visitors with an attack rate of 65% and median duration of illness of 2 days, the outbreak would have caused 260 cases and 520 days of illness, not including secondary transmission to people not present at the camp. With 15% of adults reporting having to stay home from work for a median of 3 days, and 6% consulting a physician, this would have lead to an estimated 90 lost work days (assuming 50% adults) and 16 consultations. Based on an average daily income of €150 and an average cost of one medical consultation of €90, a crude estimate of the direct costs of this outbreak would be approximately €15 000. This is probably an underestimation since secondary transmission to people not present at the camp was not taken into account, and in addition the outbreak occurred during summer when many people were on holiday, so they would not report lost work days due to illness. The costs of personal suffering and loss of well-being are not taken into account in these calculations.

Norovirus infection is a fairly benign disease and most people recover within a few days. However, there have been several more serious large outbreaks, known to have been waterborne, in developed countries in recent years, such as campylobacteriosis, shigellosis, verocytotoxin-producing *Escherichia coli* infection, salmonellosis and hepatitis A [10–12]. The need for safe water supplies, including private facilities, should therefore be emphasized. Facilities that only occasionally cater for large events need to be informed that water and sewage systems constructed for a certain number of people may not be adequate for events for which a larger number of people are staying on site.

In summary, we found that this outbreak of norovirus infection during a 2-week religious summer camp was caused by contaminated water from a drilled well. The well was probably contaminated by sewage from the camp. Drinking tap water and showering at the camp grounds were clearly associated with illness. When orders to boil water are given during waterborne norovirus outbreaks, information should also be given about possible risks of transmission through other routes, such as showering.

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