Outbreak of acute gastroenteritis caused by contamination of drinking water in a factory, the Basque Country

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ABSTRACT

On 18 September 2013, the Gipuzkoa Epidemiology Unit was notified of an outbreak of acute gastroenteritis (AGE) among employees at a domestic appliance factory. The first signs of the outbreak had emerged at the end of June and at the time of the notification 30 workers were on sick leave for gastroenteritis. Some employees had had more than one episode and the main symptoms were diarrhoea and vomiting. An investigation began to identify the causative agent, assess exposure and determine the route of transmission. Data collected by a questionnaire identified 302 episodes of AGE among 238 people affected between June and September 2013. The source of water consumed was found to be a risk factor associated with the appearance of symptoms both in the crude and the adjusted analysis: odds ratio 1.8 (0.8–4.2) and 6.4 (4.2–9.8), respectively. Microbiological analysis of stool samples and of water confirmed the presence of norovirus and rotavirus. The environmental study detected a connection between an industrial use water system and drinking water at the factory. It was concluded that the outbreak was caused by mixed viral infections, due to contamination of drinking water.

Key words | gastrointestinal disease, outbreaks, waterborne infections

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INTRODUCTION

Since the 1940s, with the detection of the Norwalk virus and rotavirus in stool samples of patients with gastroenteritis, there has been a growing recognition of the role of enteric viruses in morbidity and mortality due to diarrhoea among adults and children (Monroe 2011). Viral gastroenteritis may appear in all age groups but certain viruses tend to cause diarrhoea in specific subsets of the population. While noroviruses affect all ages, diarrhoea due to rotaviruses is most common among children <5 years of age. In industrialized countries noroviruses are responsible for 60–80% of cases of non-bacterial gastroenteritis. Rotaviruses mostly affect young children but they are also a serious cause of illness (Clark & McKendrick 2004).

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Since the introduction of rotavirus vaccines, the prevalence of acute gastroenteritis (AGE) associated with rotavirus has been falling. Among children under 5 years of age in the USA, norovirus infection has become the main cause of gastroenteritis displacing rotavirus (Payne *et al.* 2013). In Spain, there is not yet a high coverage. The vaccine is not offered free on the National Health Service since health authorities have not recommended its systematic use. It has been estimated that around 40% of the population in Spain are covered against rotaviruses (Martinón-Torres *et al.* 2011).

Water is a known vehicle for the transmission of both noroviruses and rotaviruses together with food and person-to-person (Carrique-Mas *et al.* 2002; Martinelli *et al.* 2007). Nevertheless, mixed contamination by both microorganisms is very unusual. A study in the USA found noroviruses to be responsible for 11.1% of outbreaks associated with drinking water. Deficiencies in its distribution (cross-connections and backflow) were among the causes of post-treatment contamination of drinking water (CDC 2011).

MATERIALS AND METHODS

Case definition

A case was defined as any individual who had worked at or visited the domestic appliance factory between 10 June and 30 September 2013 and experienced at least one episode of diarrhoea and/or vomiting in this period of time.

Data collection

A questionnaire was designed to collect information on age, sex, job in the company, working hours, use of the company canteen, drinking tap water at work, any gastrointestinal symptoms and date of onset and duration of symptoms. Information on whether medical attention was sought, stool samples were taken and others in the family had had similar symptoms was also gathered. This questionnaire was sent to all workers at the company ($n = 650$).

Twelve stool samples were obtained from workers who reported symptoms for microbiological analysis through the company's medical service.

Epidemiological investigation

A descriptive study of cases was conducted in terms of person, time and place including the plotting of an epidemic curve.

Subsequently, analysis was carried out to test for associations between potential risk factors (drinking of tap water at work, the source of this water, use of the canteen, contact with cases, etc.).

Statistical analysis

For the descriptive study, percentages and measures of central tendency (means and medians) were calculated. To assess associations, logistic regression models were built with the dependent variable and considering various potential confounders.

The threshold for significance was set at $p < 0.05$. The analysis was performed with IBM SPSS Statistics 21.

Environmental and microbiological investigations

Any incident related to the company's water supply prior to the start of the outbreak was investigated. Compliance to the relevant regulations in force at the time (specified in the bulletin of the Monitoring and Surveillance Unit) was checked. *In situ* analyses of the water were taken to measure residual-free and total chlorine in the water at two sites in the factory (the canteen kitchen and the dispatch area).

Information and revision of the various types of water systems in the factory (water for human consumption, for industrial use and for fire protection, as well as the wastewater system) was obtained. Cross-connections between drinking water supply and the other systems were sought. Samples of drinking water were taken at five places in the factory for physicochemical and microbiological analysis: the kitchen, expedition room, offices, rest area 1 and rest area 2.

Analysis of the drinking water was performed in the Public Health Laboratory of Gipuzkoa. The following parameters were measured: colour, turbidity, pH, conductivity, ammonium and residual free chlorine concentrations, as well as testing for bacteria (total coliforms, *Escherichia coli* B(β) glucuronidase, *Clostridium perfringens*,

enterococci and aerobic bacteria at 22 °C) and viruses (rotavirus, norovirus and hepatitis A).

Microbiological analysis of the 12 stool samples from workers was performed at the Microbiology Department at Donostia University Hospital. With multiplex real-time PCR using TaqMan® probes (Fast-Track Diagnostics), it was possible to detect genes of the following enteropathogens: bacteria (*Salmonella* sp., *Shigella*, enteroinvasive *E. coli*, enterotoxigenic *E. coli*, *Yersinia* sp., *Campylobacter* sp.), viruses (norovirus, astrovirus, rotavirus and adenovirus) and parasites (*Giardia lamblia*, *Cryptosporidium* sp., *Entamoeba* sp.).

RESULTS

Epidemiological investigation

Of the 443 individuals who completed the questionnaire, 238 reported gastrointestinal symptoms (53.7%). Among 238 individuals who became ill, there were 302 episodes of AGE. The ages of those affected ranged from 25 to 69 years; with a mean age of 44.6 years and 58.3% were men.

The onset of symptoms was on 13 June in the first case and 20 September in the last. Diarrhoea was reported by 94.4%, vomiting 41.7%, nausea 45%, abdominal pain 64.2% and fever 27.5%. A total of 64 cases experienced more than one episode. Less than a third (31%) of them sought medical attention. None was admitted to hospital and all progressed well. The minimum duration of symptoms was 1 day and the maximum 60 days, with the mean and median being 4.5 and 3 days, respectively.

The ages of those who did not become ill ranged from 28 to 61 years, with a mean of 46.5 years, and 49.8% were men.

The epidemic curve shown in Figure 1 reveals that there were two clusters of cases over the course of the outbreak. The first in June and the second, more serious, when work started up after closure of the factory for holidays.

The multivariate analysis indicated that all workers who drank water while at the factory had almost double the risk of developing gastroenteritis compared with those who did not, though the difference was not significant. However, for those who reported drinking water from the canteen the risk was 6.4-fold higher and this was statistically significant (Table 1).

Only 18 workers reported a family member having similar symptoms.

Environmental and microbiological investigations

On 20 September, the provisional physicochemical and microbiological results of the water samples pointed to microbiological contamination. The environmental investigation revealed a connection between drinking water supplies and industrial use water, which was employed in the factory for different processes.

On 23 September, definitive analysis showed high levels of bacterial contamination at two points (the canteen

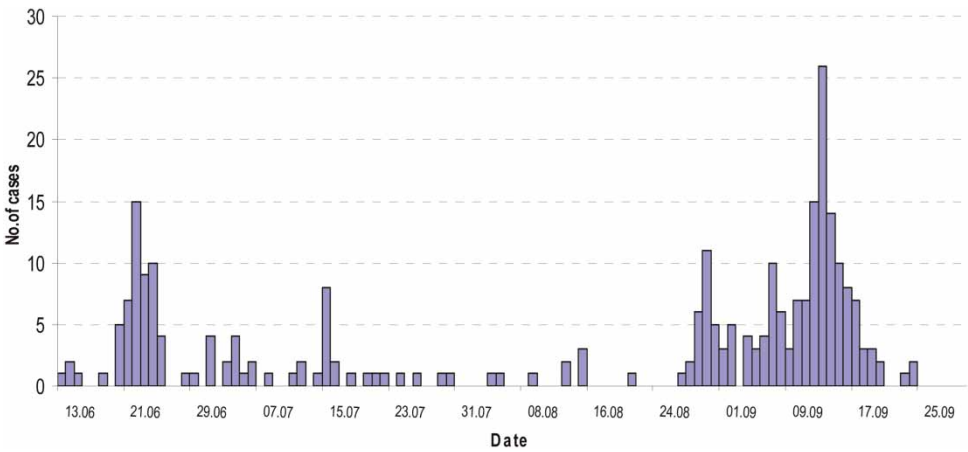

Figure 1 | Epidemic curve of the AGE outbreak.

Table 1 | Multivariate analysis of cases of gastroenteritis in a domestic appliance factory in Gipuzkoa, 2013 ($n = 443$)

Variables	Workers	Employees who reported symptoms	Odds ratio	95% CI	*p*-value
N	443	238			
Man	237	136	1.2	(0.8–1.8)	0.38
Woman	206	102			
Consumption of water at the factory[a]					
Yes	414	228	1.8	(0.8–4.2)	0.21
No	28	10			
Use of the canteen					
Yes	247	181	6.4	(4.2–9.8)	<0.001
No	196	57			

[a]1 missing.

kitchen and dispatch area) of the five sampled, and the presence of norovirus GI, norovirus GII and rotavirus.

Out of 12 stool samples analysed, 5 were negative for all the enteropathogens studied. The presence of rotavirus was detected in three, norovirus GII in two, norovirus GI in one and rotavirus together with norovirus GI in one.

MEASURES TAKEN

After the provisional results of 20 September, the initial measures taken consisted of banning the processing of food and use of drinking water throughout the factory (drinking fountains, cold water dispensers, coffee machines, etc.). A connection was discovered between the drinking water system and industrial water taken from a river (with no disinfection and only minimal treatment). The connection was blocked and the entire drinking water system was cleaned and disinfected by hyperchlorination.

On 25 September the effectiveness of this treatment was checked by taking samples at the points which had been contaminated. It was recommended that all the equipment and installations for the supply of drinking water throughout the factory were cleaned and disinfected.

The accuracy of the measures taken was checked: cleaning and disinfection as well as adequate residual-free chlorine concentrations. After all the checks were confirmed and no new cases of AGE had been reported, the cautionary ban on the processing of food and consumption of water was lifted.

On 7 October the last samples of drinking water were collected, and all results were negative.

DISCUSSION

We present an outbreak of AGE with a viral aetiology transmitted through water. At the time the outbreak was declared, there was no apparent increase in cases in the community, in other factories of the same company or in businesses nearby. The outbreak lasted from June to September, the month it was notified. When the company shut down in August there were very few new cases among the workers. The incidence of cases rose again when workers returned to work after the holidays. There were two clusters during the period of the outbreak; the second was larger in terms of number of cases. Given how long noroviruses and rotaviruses can remain infectious in water (Seitz *et al.* 2011), the fact that the second cluster of cases was larger could be due to the intake of water that had stagnated in the system (neither being used nor purged) during the holiday period, as described by other authors in school facilities (Godoy *et al.* 2006).

It was observed that there were cases among those who ate food served in the company canteen, those who ate food brought from home and those who did not eat at work. All these observations were indicative of a waterborne infection and the signs and symptoms were suggestive of a viral agent. Only 7.6% of workers who became ill reported similar symptoms in family members. Moreover, the information gathered by the questionnaire did not specify whether the episodes in other members of their family occurred before or after their illness. As mentioned above, no increasing AGE was detected in the community so probably not all cases from family members were secondary cases.

Laboratory testing of water samples is not always carried out even when there is a strong statistical association implicating water as the vector of the infection (Carrique-Mass *et al.* 2002; Nenonen *et al.* 2012; ter Waarbeek *et al.* 2010). In other outbreaks, laboratory results were not known at the time of publication (Pedalino *et al.* 2003) or it was not possible

to collect samples (Luque Fernández *et al.* 2008). In our study, the first detection of a virus was by real-time PCR in water samples and this led to the suspicion that there was some connection between the industrial and drinking water systems that could have been a source of contamination at moments when the water pressure in the system was low, as has been described previously (Kaplan *et al.* 1982).

The detection of GI and GII noroviruses in stools suggests food or water as the source of infection, though food-related outbreaks are more often associated with the GI genogroup alone (ter Waarbeek *et al.* 2010). Differences in the genogroups are significantly associated with routes of transmission and food vectors but not with water as a vehicle (Bitler *et al.* 2013). In the case of outbreaks when water is the source it is more likely that GI or GI/GII are responsible than GII alone given that the GI genotype is more stable than GII in water (Maunula *et al.* 2005; Lysén *et al.* 2009).

Information bias due to missing data could be considered a limitation of the study. The delay in the collection of data could also influence the results of our investigation due to recall bias.

CONCLUSIONS

This AGE outbreak was due to GI and GII noroviruses and rotavirus from the contamination of drinking water by industrial water from a river.

The connection mostly affected the canteen water supply and the tap in the dispatch area.

The viruses were detected both in the drinking water and the stool samples of workers with gastrointestinal symptoms.

The measures taken were successful in controlling the outbreak.

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