

## Waterborne epidemic outbreak of *Shigella sonnei* gastroenteritis in Santa Maria de Palautordera, Catalonia, Spain

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### SUMMARY

In August 2002 an outbreak of *Shigella sonnei* infection occurred in a Spanish town of 6343 inhabitants. In total, 756 people developed acute gastroenteritis and 181 cases were shigella-confirmed. The peak incidence was during 5–6 August 2002. The estimated primary attack rate was 9.97%; the attack rate for secondary cases was 38%. The <15 years age group was most affected (16.49%). The town and its surroundings were served by two water systems, A and B. The cases had consumed water provided by system A (attack rate 164 cases/1000 population). Microbiological analysis of water from system A did not show the presence of coliform bacteria or shigella. This shigellosis outbreak was the largest reported in Spain. The impact of the epidemic was probably greater than the incidence detected.

### INTRODUCTION

Shigellosis is an important health problem in developing countries but is also common in industrialized countries [1]. *Shigella sonnei*, the most frequent serogroup in developed countries, accounted for 40–57% of shigellosis infections reported between 1994 and 2002 to the Microbiological Reporting System of Catalonia [2].

In developed countries, person-to-person contact is the main mode of transmission [3], especially when

personal hygiene is insufficient, as in day-care centres [4–6]. Nevertheless, outbreaks of shigellosis due to contaminated foods [7–11] or water are not unusual [12–15].

In August 2002, an outbreak of acute gastroenteritis due to *S. sonnei* occurred in the town of Santa Maria de Palautordera (SMP). The epidemic curve and the geographical distribution of cases suggested a common source outbreak. This was the largest outbreak of shigellosis recorded in Spain. We describe the outbreak and the investigation which showed drinking water as the cause.

### BACKGROUND

The town of SMP is in the Montseny Natural Park in the province of Barcelona and has an urban nucleus

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and several housing developments. The population in 2002 was 6343, although during weekends and summer the population increases considerably as there are many second homes. The area is rich in water resources and horticulture is one of the main activities.

The municipal drinking water of SMP is supplied by two companies with totally independent networks (water taken from different rivers, and independent treatment, storage and distribution networks). Company A supplies the urban nucleus and an adjacent housing development with water taken from the Tordera River; company B supplies the remaining housing developments using water from the Ter River.

The neighbouring municipality of Sant Esteve de Palautordera (SEP) is supplied by a third company (company C) which shares the capture point in Tordera River with company A but has independent treatment, storage and distribution networks. Thus, the treatment networks of the three companies are different.

In the first days of August, the emergency department of the primary health-care centre of SMP and the closest hospital, the Sant Celoni Hospital, saw many patients with acute gastroenteritis, most with onset of symptoms between 4 and 5 August. The outbreak was reported to the Epidemiological Surveillance Unit of the Centre Region (ESUCR) of the Department of Health on 6 August and the investigation began immediately. In subsequent days, other hospitals in Catalonia reported cases related to the outbreak.

## MATERIAL AND METHODS

### Epidemiological study

A prospective, longitudinal, observational study was carried out. A case-control study would have enabled the causal relationship between the risk factor and the disease to be identified. However, an observational study was made due to the difficulties of carrying out a case-control study, which included the size of the outbreak and the resources available. August is the traditional holiday month in Spain and this resulted in staff difficulties (medical and research) and problems in tracing cases and controls.

In a sample of initial cases, data was collected on: day of onset of the disease, age, sex, address, symptoms, food and water consumed on the two previous days, and ill relatives. Only water supplied by company A was common to cases.

A specific epidemiological survey was designed including, in addition to personal and clinical data, the origin of drinking water, use of water for washing vegetables and personal hygiene, consumption of vegetables and their origin and home water systems. Most interviews were made by telephone by epidemiologists from the ESUCR. Due to the nature and extent of the outbreak, collaboration was sought from the staff of the primary health-care centre of SMP and the Epidemiological Surveillance Service of the Department of Health.

### Cases definitions

*Probable case.* All persons with two or more of the following symptoms of acute gastroenteritis: diarrhoea (two or more stools in 24 h, with or without blood or mucus), nausea and/or vomiting, abdominal pain and fever and having been in SMP (as resident or visitor) between 1 and 5 August 2002.

*Confirmed case.* A probable case with microbiological confirmation of infection by *S. sonnei* [16].

Probable and confirmed cases were further classified as primary or presumptive secondary cases.

*Primary case.* A probable or confirmed case with onset of symptoms between 1–8 August, 2002.

*Presumptive secondary case.* A person cohabiting with a primary case and whose symptoms had appeared 12–96 h after the primary case and after 9 August (when the network of company A had been cleaned and hyperchlorinated, and the supply from company A had been shut and a temporary connection made with company B to supply all the population of SMP). Cohabitation included sleeping or sharing some food at the same address as a primary case.

The cases were plotted geographically by address on the map of the area. Knowing the residence of the cases and comparing the residences supplied by companies A, B and C, we were able to perform a comparison of the incidence in the three groups and calculate the attack rates in each group and the probable differences. The attack rates were also calculated for sex and age group. The frequencies and attack rates and their 95% confidence intervals were calculated assuming a normal distribution.

The statistical analysis was carried out using the SPSS statistical program [17].

### Microbiological studies

Stool samples of the cases treated by the SMP primary health-care centre were sent to the Food Poisoning Research Support Laboratory of the Vall d'Hebron Hospital of Barcelona. In all samples, adequate culture media for the isolation of enteropathogens habitually implicated in outbreaks of food poisoning were used: *Salmonella* spp., *Shigella* spp., *Yersinia* spp., *Vibrio* spp., *Aeromonas* spp., *Campylobacter* spp. and *E. coli* O157:H7. The genus of colonies whose phenotype was compatible with *Shigella* spp. were identified using the API 20E (bioMérieux, Marcy, France) system of biochemical identification and the serotype was determined by means of agglutination on slides with specific antisera.

In order to establish the clonal relationships of the identified isolates of *S. sonnei*, the biotype and pulsed-field gel electrophoresis of restriction fragments of the chromosomal DNA were determined.

### Environmental studies

Technicians of the Section of Environmental Health and the Head Chemist of the Territorial Delegation of Barcelona of the Department of Health inspected the water supply network, analysed residual chlorine levels and obtained water samples from several points of the network. Water samples from system A were analysed in the laboratories of the Public Health Agency and the Territorial Delegation of Barcelona. Water was analysed for the presence of shigella, markers of faecal contamination (coliform organisms) and physiochemical markers (colour and turbidity of the water, oxidability to permanganate, nitrites and ammonium). Water samples from systems B and C were also analysed for residual chlorine levels, markers of faecal contamination and physiochemical markers.

## RESULTS

### Preliminary interviews

A pilot study showed that the persons affected were grouped geographically in the urban centre of SMP and on the housing developments, and had no other factor in common. All persons affected were supplied with water by company A. During the first days of the

investigation, no affected persons receiving water from company B were found. Affected persons who did not live in SMP but had visited the municipality before the onset of symptoms were found, and again, the only common factor was consumption of water supplied by company A.

### Epidemiological study

From 1 August to 23 September 2002, 756 cases were detected: 67% were reported by the primary health-care centre, 16% by Sant Celoni Hospital, 7% by other centres and 10% detected by ESUCR through interviews with patients. Interviews were conducted with 288 cases (38%). The remaining cases could not be located, although since they had been attended by the SMP primary health-care centre or Sant Celoni Hospital, basic information such as age, sex, address, disease onset and type of symptoms was obtained.

The first cases became ill from 1 August onwards; the peak incidence was on 5 and 6 August (Fig. 1). Eighty per cent of cases (603) were residents of SMP, and the remaining cases either had a second home in SMP or had visited the village between 12 and 96 h before the onset of symptoms. All cases were located in the area supplied by water system A, either in the urban nucleus or in one of the adjacent housing developments (Fig. 2).

The estimated global attack rate in the resident population of SMP was 9.97% (603 cases). The study of the incidence of cases distributed geographically in SMP and SEP and related to the different water companies showed a rate of 164 cases/1000 population (95% CI 151–177) for company A; 1.5 cases/1000 population (95% CI 0.1–2.9) for company B; and 4.4 cases/1000 population (95% CI 1.1–7.6) for company C. There were cases in all age groups although the highest attack rate was in children <15 years of age (Table 1).

In two communities in which complete information on exposure was available, the attack rate was higher. In a youth hostel, the attack rate of primary cases (probable and confirmed) was 60% and in a nursing home 83%.

Classifying cases according to onset of symptoms from 9 August onwards, 17% of cases were presumed secondary. Among cases with onset of symptoms from 9 August onwards, 16 were not included as presumed secondary cases as they had no relationship with any primary case, but had consumed water from private wells, network water without draining and/or

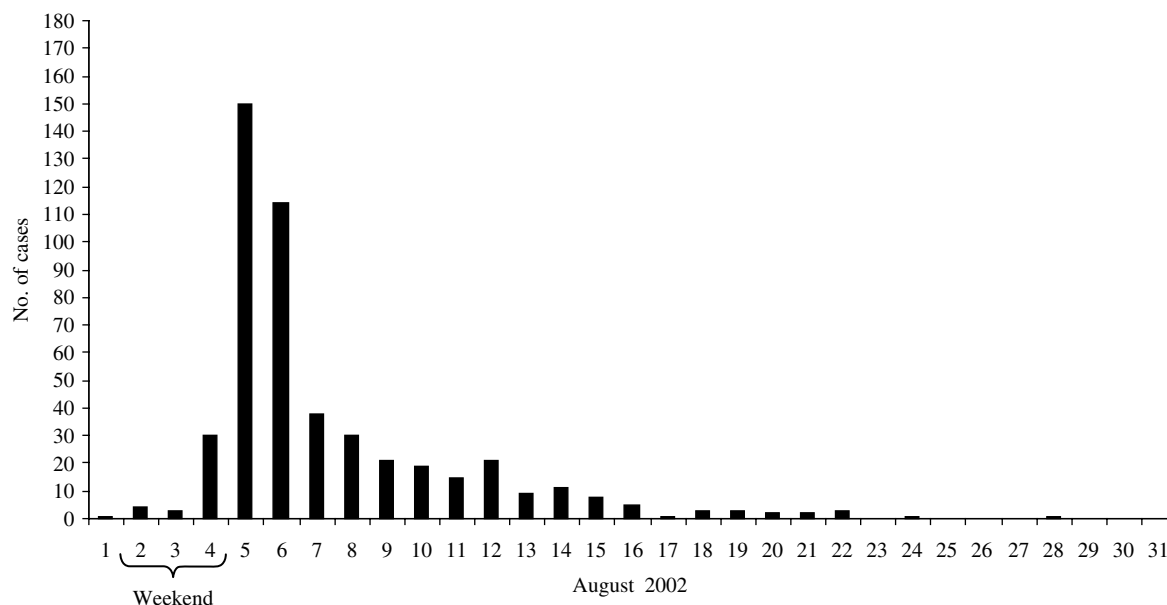


Fig. 1. Epidemic curve. Distribution of cases detected during August 2002.

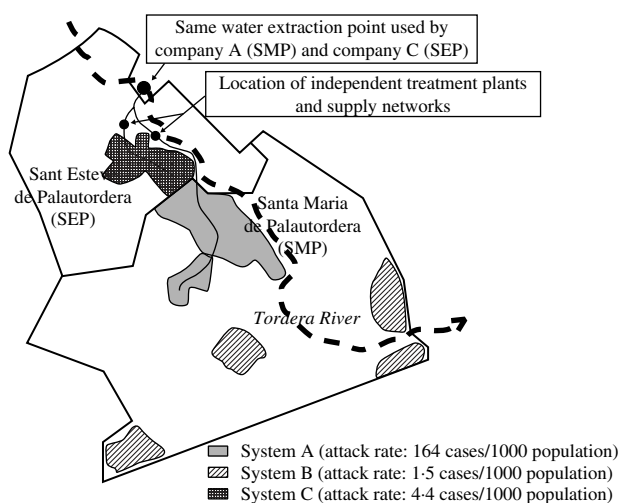


Fig. 2. Map of Santa Maria de Palautordera. Geographical distribution of water supplied by different companies (attack rate). Location of water extraction point used by companies A and C and location of water treatment plants and supply networks.

vegetables watered with untreated water from the same source as water system A.

In 72 families with primary cases and complete information on water consumption, the attack rate for secondary cases was 38%.

The symptoms were similar in probable and confirmed cases: profuse diarrhoea (98% of the cases), diarrhoea with blood/mucus (10%), abdominal pain (90%), fever  $\geq 39^\circ\text{C}$  (84%), and vomiting (49%). Hospital admission was necessary in 1.8% of cases.

Water from the network was used by 85.5% of primary cases for drinking, 86.1% for brushing teeth and 81.2% for washing raw fruit and vegetables, while 14.4% drank water from natural sources. Thirty-one per cent of cases interviewed stated that the tap water tasted bad or looked cloudy during the days previous to the outbreak.

#### Laboratory findings

Samples for stool culture were obtained in 247 cases; 181 (24% of cases detected) were confirmed with positive stool culture for *S. sonnei*, without detection of other enteropathogens. All strains showed the same profile of resistance to cotrimoxazole and tetracyclines and were sensitive to the remaining antibiotics. All the *S. sonnei* strains belonged to biotype g and showed the same restriction pattern. Figure 3 shows some representative profiles of isolations from the outbreak with identical chromosomal DNA patterns.

#### Environmental investigation

It rained heavily in the area on 31 July and 1 August, resulting in mud and organic material entering the treatment plants. The records of company A were reviewed to determine levels of residual chlorine and microbiological controls in the days previous to 6 August, the values of free residual chlorine obtained were not sufficient to resist the contamination of the network.

Table 1. Numbers and attack rates of by age and sex

Age (yr)	Number of cases			Attack rates (per 100)		
	Male	Female	Total	Male	Female	Total
0–14	79	74	153	16.19	16.81	16.49
15–44	102	108	210	6.73	7.62	7.16
45–64	24	37	61	3.67	5.77	4.71
≥65	26	39	65	6.45	7.97	7.29
Unknown	65	49	114	—	—	—
Total	296	307	603	9.68	10.27	9.97

Company C, which supplies SEP, interrupted the entrance of water to their treatment plant on 31 July. The company's records show that all samples of levels of residual disinfectant in their network during the days 1–6 August were >0.5 ppm (Table 2).

Company B did not take any special precautions because their water supply was from another river far away, which was not implicated in the rain which fell on SMP. This company supplied several important towns in Catalonia but no cases of shigella were reported.

After the declaration of the outbreak, the facilities of the supply system of company A were inspected and samples taken from different points of the system. None of the samples, which were all taken after 6 August, showed markers of microbiological contamination or shigella.

### Control measures

Control measures included the hyperchlorination and cleaning of the network of company A during 7–8 August; emergency water supplies using buckets and switching the system of company B to company A for 5 days (Table 2); improvement of treatment conditions of the water provided by company A; health education of families of the cases, and antibiotic treatment of the cases according to the antibiogram.

All water samples analysed from the network of company A after the adoption of control measures indicated that the water was fit for human consumption.

### DISCUSSION

Shigellosis is one of the most transmissible forms of bacterial diarrhoea. Experiments with volunteers have shown that fewer than 200 viable cells are

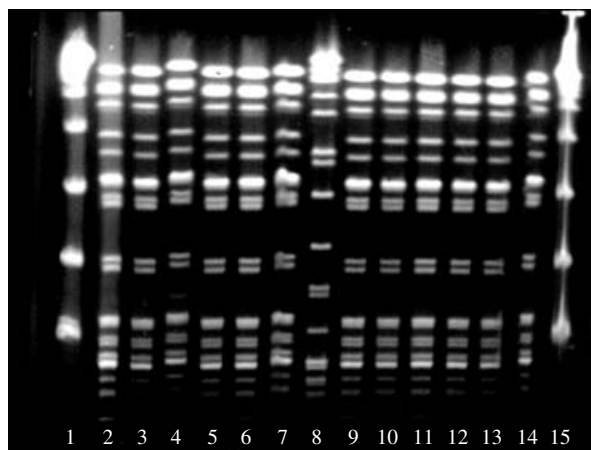


Fig. 3. Electrophoresis profiles of 12 representative *Shigella sonnei* isolations from the outbreak. Lanes 1, 15, marker of molecular weight (lambda ladder PFG marker); lanes 2–7 and 9–14, strains of *Shigella sonnei*; lane 8, pattern strain (*Salmonella enterica* serovar Braenderup).

needed to readily produce the disease [18, 19]. This favours person-to-person transmission, triggering sporadic cases or family outbreaks, or may cause more extensive secondary transmission following a common source [12, 20]. Outbreaks of acute gastroenteritis due to shigellosis have been associated with foods such as salads, lettuce, corn and sandwiches [7–10, 19, 21] and also, in many cases, with water supplies [13, 14, 22–25] or recreational water pursuits [15, 26, 27]. In Spain, shigellas are one of the most common waterborne agents involved in outbreaks of gastroenteritis [28, 29].

Our present study investigated the relationship between a waterborne outbreak of *S. sonnei* and the water of the municipal network of SMP supplied by company A. Although the causal agent was not isolated from the samples taken, various factors suggested that this relationship existed. The attack rate for the population supplied by company A was 164 cases/1000 population compared with 1.5 cases/1000 population and 4.4 cases/1000 population for companies B and C respectively. Moreover, all cases detected in homes supplied by companies B and C had been in the urban centre of SMP (supplied by company A) and had drunk from public drinking fountains, reinforcing the hypothesis of a common origin. The environmental study showed that heavy rain on 31 July and 1 August produced a significant movement of mud leading to a deterioration in the water quality at the capture point, a treatment plant whose facilities were not designed to treat very turbid water. Non-specialized staff were not capable of



Table 2. *Environmental data: dates of control measures*

Date	Backgrounds Control measures	Company A Control 1 <sup>a</sup>	Control 2 <sup>b</sup>	Company C <sup>c</sup>
31 July	Heavy rain Contamination by mud	Residual f-c <sup>d</sup> : 1 ppm Coliforms <sup>e</sup> : Absence		
1 August		Not tested		Residual f-c: 0.7 ppm
2 August		Residual f-c: 0.1 ppm		Residual f-c: 0.6 ppm
3 August		Residual f-c: 0.2 ppm		Residual f-c: 0.7 ppm
4 August		Residual f-c: 0.2 ppm		Residual f-c: 0.6 ppm
5 August		Residual f-c: 0.2 ppm		Residual f-c: 0.5 ppm
Epidemic outbreak declared				
6 August	Company A supply shut		Residual f-c: 0.6 ppm Coliforms: Absence	
7 August	Cleaning, hyperchlorination of company A		Residual f-c: 2 ppm Shigella: Absence	
8 August			Residual f-c: >2 ppm	
9 August	Connection with supply of company B	Coliforms: Absence	Residual f-c: 0.2–2 ppm	
13 August	Water supply of company A re-established	Residual f-c: >1 ppm	Residual f-c: 1.2 ppm Coliforms: Absence	

<sup>a</sup> Control made by company A; <sup>b</sup> controls made by Section of Environmental Health in company A; <sup>c</sup> controls made by company C; <sup>d</sup> Residual free-chlorine; <sup>e</sup> presence of coliforms.

preventing the possible contamination from the river and supplied water with levels of chlorine inferior to those recommended.

Other factors supporting this hypothesis were: (1) the epidemic curve, with an explosive presentation of cases at the beginning of August; (2) the clinical data of the cases, who had similar symptoms; (3) the faecal samples showing strains of shigella with the same antibiotic sensitivity, biotype and restriction profile patterns; and (4) the absence of any other common factor, apart from the consumption of water, which might explain the magnitude of the outbreak.

Shigellas are difficult to culture from water and isolation from water is unusual [12, 13, 22, 24, 30]. Their survival time in water is limited unless it is grossly contaminated with sewage. Furthermore, the water samples from the network of company A were collected after the peak of the outbreak when adequate chlorination had been restored.

The impact of the epidemic was probably greater than the incidence detected. The real number of cases was clearly far greater than those reported: on a crude estimate, the ratio of actual to reported cases was about 7:1, making a total of 5000 cases (estimated). Moreover, we believe that a significant number of visitors with mild symptoms did not contact any health services.

To our knowledge this was the largest outbreak of shigellosis reported in both Catalonia and Spain. It occurred in a developed country with mains water supplies which are normally of a very high quality. The main objective of the investigation was to determine not only the impact of the outbreak but also the cause and the establishment of immediate control measures to limit the outbreak and avoid further outbreaks. Epidemiological surveillance and environmental hygiene measures are fundamental in preventing waterborne outbreaks, and chlorination and health controls on water are vital.

#### APPENDIX. Outbreak Working Group members

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## DECLARATION OF INTEREST

None.

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