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A waterborne outbreak of small round structured virus, campylobacter and shigella co-infections in La Neuveville, Switzerland, 1998

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SUMMARY

An outbreak of gastro-enteritis occurred in La Neuveville, township with 3358 inhabitants. A retrospective cohort study of 1915 participants showed that 1607 (84%) had been ill. *Campylobacter jejuni* was isolated from 28 patient faecal samples, *Shigella sonnei* from 21 patients and small round structured viruses (SRSV) from 6 patients. More than one pathogen was identified in eight persons. The epidemic curve was characteristic of a point-source outbreak. The risk for illness was significantly higher among persons who had drank unboiled drinking water than among those who had not (1290 [80·3%] of 1607 *vs.* 86 [27·9%] of 308; RR = 2·87; 95% CI 2·40–3·45). Risk increased significantly with the quantity of water consumed ($P < 0{\cdot}00 \times 10^{-6}$). An SRSV isolate from water and one human faeces had an identical DNA sequence. The outbreak was due to a pump failure producing a spill of sewage into the groundwater. We conclude that transmission was waterborne and that measures including early warning, basic hygiene and sanitation improvements controlled this epidemic.

INTRODUCTION

Few outbreaks of waterborne disease have been described in Switzerland. The 1963 Zermatt *Salmonella typhi* point-source epidemic was due to a combination of leakage of sewage, temporary breakdown of chlorination and possible contamination of the water-holding tank by a carrier [1]. Between 1988 and 1997 only five waterborne outbreaks were notified to the Office of the Canton Physicians, in charge of epidemiological investigations, and the Swiss Federal Office of Public Health as part of the national quality water surveillance. In two of these outbreaks (in 1991 with 40 cases and in 1992 with 60 cases) *Escherichia coli* was implicated, in two others (in 1995 with 16 cases and in 1995 with 100 cases) *Campylobacter jejuni* [2], and in the remainder (in 1997 with 15 cases) echovirus was confirmed [3].

Despite the paucity of reports, enteric infections transmitted by faecal–oral route are endemic in Switzerland. Between 1995 and 1997 laboratories notified 5000–6000 campylobacter isolates per year to the Swiss Federal Office of Public Health, and about ten times less shigella isolates (Table 1). Over the same period, La Neuveville district recorded 16 campylobacter and 4 shigella infections, and Bern Canton, in which the district is located, recorded 2 outbreaks, mentioned above, of campylobacter in 1995 and echovirus in 1997. Another epidemic in October 1997 that was not investigated resulted in at least 30 cases of acute gastro-enteritis in La Neuveville. Initially inhabitants requested a bacteriological investigation

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Table 1. *Campylobacter and shigella notifications 1995–8, Switzerland, Bern Canton and La Neuveville*

	Campylobacter				Shigella			
	1995	1996	1997	1998	1995	1996	1997	1998
Switzerland	5044	5660	5955	5458	533	439	625	500
Bern	487(9·7)*	577(8·8)	539(9·1)	517(9·4)	45(8·4)	47(10·7)	49(7·8)	76(15·7)
La Neuveville	8	3	5	18	2	1	1	10

* Bern Canton notifications as a percentage of Swiss notifications.

Table 2. *Results of microbiological quality tests of water*

	Legeally required standards[4]		Date of test				
Water-type	GW*	WSS†	14.10.97 GW	29.8.98 GW	29.8.98 WSS	1.9.98 GW	1.9.98 WSS
Aerobic, mesophilic agents/ml	100	300	>300	>10000	>10000	5000	5000
Escherichia coli/100 ml	nd‡	nd	>200	>5000	>10000	>300	>500
Enterococci/100 ml	nd	nd	4	>140	>1000	nd	nd
Shigella spp./5000 ml						nd	nd
Salmonella spp./5000 ml						nd	nd
Enterovirus/1000 ml				nd	+§		
SRSV/1000 ml				nd	+		

* GW, groundwater.
† WSS, water supply system.
‡ nd, not demonstrated.
§ Detected.

of the water because of visual impurities and faecal organisms contaminants were recovered (Table 2). Contamination was due to a leakage of sewage in the water caption zone and due to maintenance work, the pumps had also been switched off.

In Switzerland, the alimentary code regulates responsibilities and standards for drinking water [4]. Communal authorities are obliged to provide safe water to subscribers and are responsible for continuous chemical and bacteriological quality surveillance. In Bern Canton as in all Cantons, the minimum frequency of laboratory analyses depends on the size of the community (about one control per year per 500–2000 inhabitants) and in the case of La Neuveville, the minimum requirement is two bacteriological and one chemical analysis a year. In 10 years (1982–91) 413000 drinking water samples were examined in Switzerland and 53000 (13%) did not correspond to legally required standards, in 40% because of the presence of enterobacteriaceae or *E. coli* [5].

La Neuveville is a township with 3358 French-speaking inhabitants at the bottom of the Jura mountain chain in Bern Canton. The township is located on the shore of Lake Bienne and is surrounded by vineyards. Each house is connected to the community water supply and sewage systems, the latter being about 30 years old. The part of the system near to the lake is located below the groundwater level and for that reason a pump is necessary to transport sewage to the central purification plant. The two installations for pumping drinking water from the groundwater are located in the same area as the sewage pump at the lakeside. The VYREDOX-method of natural filtration with injection of pure oxygen into the groundwater is the treatment method used for drinking water.

We report here the investigation of an outbreak of small round structured virus (SRSV), shigella and campylobacter co-infections in La Neuveville in 1998 which was linked to contaminated drinking water.

METHODS

Microbiology

Drinking water samples were examined in the Canton Laboratory for aerobic, mesophilic agents, *E. coli* and enterococci according to methods of the Swiss

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Alimentary Codex [6], and separately for *Shigella* spp. and *Salmonella* spp. Samples were also examined in the Laboratory of Food Chemistry, Department of Chemistry and Biochemistry, University of Bern, for enteroviruses and SRSV by reverse transcriptase–polymerase chain reaction (RT–PCR). Stool samples were examined by standard methods for Gram-negative bacteria, *Cryptosporidium* spp. and other protozoa by direct microscopy and by RT–PCR for enteroviruses and SRSV. *C. jejuni* and *S. sonnei* isolates were confirmed by the National Center for Enteropathogens (NENT) where they were typed by restriction fragment length polymorphism (RFLP) of a flagellin gene and ribotyping respectively.

Epidemiology

A questionnaire was distributed to all households on 10 September 1998 for the retrospective cohort study. Demographic data (birth-date, sex, address), clinical characteristics (symptoms, onset of illness, physician and pharmacy visits, hospitalization) and exposure (drinking of unboiled water and quantity) were requested. The question on water quantity was phrased: between 24 August and 1 September 1998, how many times a day did you drink unboiled water from the faucet? Parents or guardians responded for children. As enterobacterial infections were suspected initially, a case was defined as: (a) present in La Neuveville between 24 August and 1 September 1998 *and* (b) inhabitant of La Neuveville with acute diarrhoea (probable case) *or* fever, flu-like symptoms (headache, myalgia), nausea, vomiting or abdominal pain (possible case).

Analysis

Exposure to drinking water was divided into six categories of increasing quantity: 0 = none, 1 = rinsing of mouth or brushing of teeth, 2 = washing of vegetables, 3 = drinking once a day, 4 = drinking 2–5 times a day, 5 = drinking $\geqslant$ 6 times a day. To identify the most likely period of exposure from the epidemic curve, the following minimal and maximal incubation periods were assumed: 0·5 and 7 days for shigella infections and 1 and 7 days for campylobacter infections. Coordinates of buildings provided by the Swiss Federal Office of Statistics in a geographical information system were used for spatial analysis of cases. χ^2 and 95% confidence intervals were calculated in Epi-Info Version 6 (Centers for Disease Control and Prevention, Atlanta, USA) to test significance. A one-sided significance level of $\leqslant$ 5% was selected.

RESULTS

Events

On Friday afternoon, 28 August 1998 the first patients sought medical attention in La Neuveville. On Saturday, 29 August 1998, the same physician who had reported the first outbreak in 1997, informed the office of the Canton Physician of some 20 patients with vomiting and diarrhoea. Because of his past experience he suggested contaminated drinking water as the possible source and so the Canton Laboratory collected samples from groundwater and water supply system, and ordered preventive manual chlorination of water in tanks.

The first results of water analyses on Sunday, 30 August 1998, revealed faecal contamination of the whole water supply system, and of the groundwater (Table 2). On the same day, the population was advised to boil drinking water as a preventive measure. Since leakage of sewage was the suspected cause, the Canton Laboratory, the Office of Water Energy, responsible for the piping of drinking water, and the Office of Water Protection, responsible for sewage system, initiated further investigations. At the request of the Canton Laboratory, communal authorities distributed written instructions to all water subscribers on Monday, 31 August 1998. Also on the same day machinery for continuous water chlorination was provisionally installed at the groundwater pump house and was operative by the evening of 1 September 1998. However, drinking water quality remained poor. Therefore, when safe water was diverted from two neighbouring communities, the township groundwater supply was shut down on 2 September 1998. Further that day following the first report of a *S. sonnei* infection, the Canton Physician prompted a media release with recommendations for personal hygiene. The next day, *C. jejuni* was reported from the same patient.

On 4 September 1998 the Canton Physician, in accordance with the Canton Laboratory and the organizing committee, cancelled the festival of vine-growers of 5–6 September 1998 in La Neuveville owing to the high risks of faecal-oral transmission in a large number of expected visitors. On 8 September 1998 the population was again informed about the isolation of virus from stool and drinking water specimens, taken on 29 August 1998.

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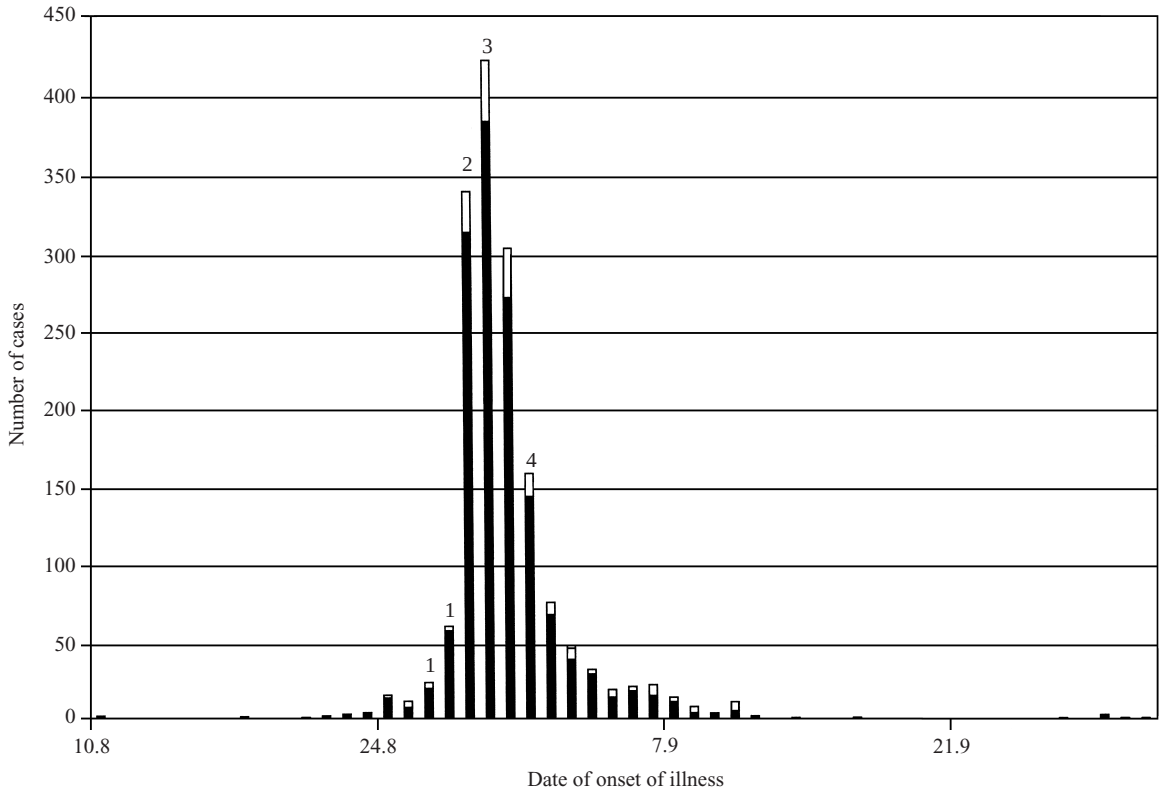

Fig. 1. Epidemic curve – Number of *probable* (■) and *possible* cases (□) by date of onset of illness, La Neuveville, 10 August – 30 September 1998. Numbers indicate the following events: 1, Pump failure (27 and 28 August); 2, Notification to the Office of the Canton Physician (29 August); 3, Boiling of drinking water and manual chlorination of tank water (30 August); 4, Access to groundwater from neighbouring communities and continuous chlorination (2 September).

By chlorination and flushing, faecal bacteria were removed, so that on 10 September 1998 (i.e. 1 week after tapping neighbour communities supplies) drinking water of the whole water supply system in La Neuveville corresponded to legally required standards. On 12 September 1998 subscribers, after having flushed their house water taps, were allowed to use drinking water without any restriction. Repair work, upgrades (machinery for ultraviolet and continuous chlorination) and risk evaluation prescribed by Cantonal authorities were completed on 21 June 1999 and the community finally resumed use of its groundwater supply.

Microbiology

One or more pathogens were isolated from 48 faecal samples: *C. jejuni* was recovered from 24 samples, *S. sonnei* 17 samples, both organisms on 4 occasions, SRSV 6 samples (2 alone and 4 co-infections) and enteropathogenic *E. coli* twice (once alone and the other with *S. sonnei*). All *S. sonnei* isolates submitted to NENT were of the same ribotype. In contrast, isolates of *C. jejuni* fell into two RFLP groups. Because some isolates of both RFLP groups were co-isolated with *S. sonnei*, it was assumed that both *C. jejuni* RFLP groups were epidemic strains. Only one isolate of *C. jejuni*, exhibited a profile distinct from the two RFLP groups and this was considered unrelated to the epidemic. Of the 6 SRSV, 5 were of genotype 2 and 1 of genotype 1. In a water sample of 29 August 1998, enteroviruses and SRSV of genotype 1 were identified (Table 2). The DNA sequence of the genotype 1 SRSV recovered from drinking water was identical with the sequence of the SRSV, also of genotype 1, recovered from a patient.

Epidemiology

National notification figures did not signal an increased case load during the outbreak period. In contrast, case reports in La Neuveville district in 1998 increased, for campylobacter by about three fold to 18, for shigella by more than fivefold to 10 (Table 1) confirming the existence of an outbreak and this was underlined by the epidemic curve shown in Figure 1. Considering probable cases only, the likely onset of

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Table 3. *Symptoms reported by 1607 ill inhabitants identified in cohort-study, La Neuveville, 10 August – 30 September 1998*

	Probable cases* ($n = 1431$)	Possible cases* ($n = 176$)
Diarrhoea	100·0†	0†
Fever	55·3	38·1
Nausea	2·9	10·3
Vomiting	46·4	39·2
Abdominal pain	15·3	31·8
Flu-like	26·8	37·6

* Case definition: present in La Neuveville between 24 August *and* 1 September 1998 *and* inhabitant of La Neuveville with acute diarrhoea (probable case) *or* fever, flu-like symptoms (headache, myalgia), nausea, vomiting, or abdominal pain (possible case).
† Percentage with symptom.

the outbreak was 24 August 1998, and its likely end was 7 September 1998, for a duration of 15 days and a peak on 29 August 1998 with 422 cases (383 probable and 39 possible). The most likely time of exposure was between 23 August 1998 and 1 September 1998.

A total of 2011 (60%) of 3358 inhabitants responded to the questionnaire. In addition, 249 questionnaires were received from persons staying in La Neuveville for work, school, or other reason (216 (87%) of them said to have been ill). Ninety-six questionnaires were excluded from analysis: 27 of persons away from La Neuveville during the exposure time and 69 with missing date of onset of illness. This left 1915 (57%) valid questionnaires and 1607 (84%) of participants recorded having been ill between 10 August 1998 and 30 September 1998, and only 308 (16%) claimed to be unaffected. Of those ill, 1431 (89%) had acute diarrhoea (probable cases) and 176 (11%) had other symptoms (Table 3). Their median age was 39 years (range 2 months to 96 years); 889 (55%) were females and 718 (45%) were males. More patients (869 or 54·1%) consulted a pharmacist than a physician (625 or 38·9%) either by telephone or by office visit; 34 patients (2·1%) were hospitalized.

Attack rates were similar in females (85%) and in males (82%), but children ($\leqslant$ 16 years) had a significantly higher ($P < 0{\cdot}00 \times 10^{-6}$) attack rate (Table 4). Consumers of unboiled drinking water between 24 August 1998 and 1 September 1998 had a nearly three times higher (80·3% [1290 of 1607]) attack rate than non-consumers during this period (27·9% [86 of 308]), a difference which was highly significant ($P < 0{\cdot}00 \times 10^{-6}$). Thus, the relative risk to become ill after consumption of unboiled drinking water was 2·87 (95% CI 2·40–3·45). Attack rates also significantly ($P < 0{\cdot}00 \times 10^{-6}$ for trend) increased with the level of exposure (Table 5). Attack rates by streets or neighbourhoods did not provide evidence of clusters along main sewage or tap water lines. In contrast, site inspections by the office of water protection demonstrated that a temporary pump failure on 27 and 28 August 1998 in a sewage collecting shaft caused congestion in connecting pipes, high pressure and overflow of sewage into the environment including groundwater. The pump alarm system had been switched off years previously because of frequent false alarms due to technical problems.

Table 4. *Risk for gastrointestinal illness related to age, La Neuveville, 10 August – 30 September 1998*

Age (years)	Cases	Total	Attack rate (%)
0–7	194	205	94·6*
8–16	183	191	95·8*
> 16	1230	1519	81·0
Total	1607	1915	83·9

* $P < 0{\cdot}00 \times 10^{-6}$.

DISCUSSION

Our investigations point to five, if not six, simultaneously occurring human pathogens as the cause of this epidemic: two epidemic strains each of *C. jejuni* and of SRSV, one common strain of *S. sonnei* and, possibly, enteropathogenic *E. coli*. Humans are the sole or main reservoir of SRSV and *S. sonnei*. For *C. jejuni*, in 1983–98 only seven drinking water associated outbreaks have been reported involving 44–2400 cases

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Table 5. *Risk for gastrointestinal illness and quantity of water consumed, La Neuveville, 10 August – 30 September 1998*

Water use	Cases	Total	Attack rate (%)*
None	253	468	54·1
Rinsing mouth or brushing teeth	33	37	89·2
Washing of vegetables	33	36	91·7
Drinking once a day	189	221	85·5
Drinking 2–5 times a day	935	983	95·1
Drinking $\geqslant 6$ times a day	164	170	96·5

* $P < 0{\cdot}00 \times 10^{-6}$ for trend.

[7–13]. As for shigella, many drinking water associated outbreaks have been documented both in the US [14–19], Europe [20–22] and elsewhere [23–26]. However, reports on outbreaks related to multiple pathogens are infrequent [27] as a massive influx of sewage into a water supply system, that would favour multiple pathogens, is a rare event in industrial countries. Moreover, waterborne viruses are not yet included into the systematic drinking water quality control procedures. Aerobic mesophilic agents, *E. coli* and enterococci are currently used as faecal indicator agents in Switzerland but this study shows that this should be extended to campylobacter as part of an expanded investigation of contaminated drinking water. Only since 1997, and on suspicion of microbiologic contamination, has Bern Canton requested virological analysis of water samples in addition to routine examination.

In the first water sample of 29 August 1998, enteroviruses and SRSV were found. *Shigella* spp. were not recovered from water samples of 1 September 1998 (Table 2), which was a major argument not to attempt to isolate campylobacter as well. Sewage influx of short duration and rapid chlorination could explain why shigella was not found in drinking water. Nevertheless, for the following reasons [28] the La Neuveville outbreak was most likely waterborne (i) samples from the first day of the outbreak demonstrated faecal contamination of both water supply system and groundwater (Table 2); (ii) a SRSV isolate from drinking water and another from human faeces had an identical DNA sequence; (iii) the epidemic curve was typical for a point source outbreak; (iv) the risk for illness was significantly higher among persons who had drunk unboiled water than among those who did not and risk increased significantly with quantity of water consumed, and (v) specific interventions brought the outbreak rapidly under control.

In Switzerland the alimentary code not only requires stringent controls at critical points such as pumps and chlorination machinery, but also interventions in the case of breakdown or if tolerated levels are exceeded [4]. While the code defines tolerated levels (at which drinking water can be used without health risk), it does not define critical levels (at which drinking water can no longer be used because of health risks). Repair, maintenance and renewal of sanitary infrastructure, costly and dependent on political will as it may be, remains, however, a necessity to guarantee the supply of safe water.

Without rapid response waterborne outbreaks can become large epidemics, involving thousands of victims [29]. In La Neuveville, with an attack rate of 84% among participants in the retrospective cohort study, the impact of the epidemic was huge. Assuming that because of selection bias the attack rate among participants of the cohort study was twice that among non-participants (42%: 606 of 1443), the estimated number of cases is 2213. For comparison, the 1963 Zermatt *S. typhi* outbreak caused 437 cases [1] and a campylobacter outbreak in 1981 by raw milk > 500 cases [30]. In the first days of the outbreak health services in La Neuveville reached their limit, both with regard to patient care and drug supplies. The 2213 cases is a minimum estimate as visitors who had attack rates similar to township residents (87 *vs.* 84%) were excluded from analysis because of uncertainties about denominator and exposure. Further, as a high proportion of cases consulted pharmacists, considerable underreporting of laboratory findings is likely. In contrast, enhanced surveillance in neighbourhood communities did not detect person-to-person spread.

It is our experience that the population frequently and rapidly contacts communal authorities for complaints of taste, smell or turbidity of drinking water and requests for quality control. Such inquiries could

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serve as an early warning system. Repeatedly, outbreaks were first recognized by astute lay persons [31] or medical personnel [32], before routine run of algorithms through central databases [33]. Continuous measuring of turbidity of drinking water may add to early warning [34].

This study underscores the importance of close cooperation between all responsible authorities and commitment to unpopular decisions (such as cancellation of the festival of vine-growers) for rapid control. However the most important control measure was early and extensive information of the population through local and national media, along with the recommendation to boil drinking water and to follow good personal hygiene. In this way, secondary cases and a protracted course of the outbreak were averted.

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