Case Study: Waterborne Outbreak of Acute Infectious Gastrointestinal Disease in 2000 in the community of Walkerton, Ontario, Canada

WATERBORNE OUTBREAK OF GASTROENTERITIS ASSOCIATED WITH A CONTAMINATED MUNICIPAL WATER SUPPLY, WALKERTON, ONTARIO, MAY-JUNE 2000

This report describes the findings of investigations led by the Bruce-Grey-Owen Sound Health Unit (BGOSHU) with the assistance of Health Canada and the Ontario Ministry of Health and Long-Term Care into an outbreak of gastroenteritis in Walkerton, Ontario, in May and June 2000. The purpose of these investigations was to determine the scope, the likely cause, and the contributing factors of the outbreak. This incident represents the first documented outbreak of *Escherichia coli* O157:H7 infection associated with a treated municipal water supply in Canada and the largest multi-bacterial waterborne outbreak in Canada to date.

Identification of the Walkerton outbreak was initiated by the early recognition of pediatric cases of bloody diarrhea and severe abdominal cramps from Walkerton reported to the BGOSHU on 19 May 2000. After inquiries by the Health Unit revealed an increase in diarrheal illness in long-term care facilities, elementary schools, and emergency departments in the Walkerton area, an outbreak investigation was launched. While most of those ill were residents of Walkerton, a number of individuals lived in outlying communities. Two days of exhaustive investigation failed to identify any common foodborne exposure or community event that could account for the cases. Residing in or visiting Walkerton was the only common factor among those ill. The municipal water supply appeared to be the only plausible vehicle for such a widespread outbreak.

A stool culture taken from one of the initial cases was reported on Saturday, 20 May, to be presumptive positive for sorbitol negative *E. coli* (a marker for *E. coli* O157:H7), and a preliminary report early on 21 May identified the stool culture isolate as *E. coli* O157. Despite reassurances from the Walkerton Public Utilities Commission (PUC) that the water was safe and secure, a Boil Water Advisory was issued to the town of Walkerton by the Health Unit at 13:30 h 21 May. Subsequent testing of the municipal water distribution system confirmed contamination with *E. coli* and coliform bacteria.

On 22 May, the BGOSHU made a request to the Ontario Ministry of Health and Long-Term Care for a federal field epidemiologist to assist. Due to the nature and scope of the outbreak, a team of epidemiologists from Health Canada was assembled and dispatched to Owen Sound. The Ontario Ministry of Health and Long-Term Care also provided an epidemiologist to collaborate in the investigation.

The epidemiologic investigation included both a descriptive study and a cross-sectional study. Intensive case-finding for the descriptive study ultimately led to the identification of 1,346 reported cases of gastroenteritis who had been exposed to Walkerton municipal water. Among these, 799 were residents of the town of Walkerton. Based on estimates derived from the cross-sectional study, the number of Walkerton residents who became ill was approximately 1,286. The estimated overall number of cases associated with the outbreak exceeded 2,000.
Of the 1,346 reported cases identified, 1,304 were considered to be primary (exposed to Walkerton municipal water), 39 were secondary (exposed to a primary case and not to Walkerton municipal water), and three were unclassified. In total, stool samples from 174 people had presumptive laboratory evidence of *E. coli* O157, 167 of which were confirmed as *E. coli* O157:H7. Stool samples from 116 people were confirmed with *Campylobacter* species (spp.). Sixty-five patients were admitted to hospital, and of these, 27 developed hemolytic uremic syndrome. Six people died as a result of the outbreak.

The median age of reported cases was 29 years (range < 1 to 97 years); 57% were female. While 92% of those ill resided in Bruce and Grey Counties, 8% of cases resided in other parts of the province, and two individuals lived in other provinces.

The onset for illness of the majority of reported cases occurred after 12 May and continued until late June. Although most became ill between 16 and 26 May, several cases were identified with onset dates as early as 15 April. This included some individuals infected with the same strain of *E. coli* O157:H7 as the majority of the outbreak cases according to genetic finger-printing. Based on these early onset cases and several water samples positive for coliform bacteria taken in April, it is possible that low numbers of bacteria were entering the Walkerton municipal water distribution system in April and early May. It is hypothesized, however, that heavy rainfall in mid-May was responsible for gross contamination of the distribution system resulting in the majority of the illnesses. Mapping of the cases in Walkerton by location of residence confirmed the widespread nature of the illnesses and supported the hypothesis that municipal water was the cause of the outbreak.

Analyses of the cross-sectional study of Walkerton households, conducted in June, confirmed that people residing in homes connected to the municipal water supply and consuming Walkerton water were 11.7 times more likely to develop gastroenteritis than those not exposed to Walkerton water. A dose response relationship was demonstrated in that the risk of illness increased with the quantity of water consumed. This study also found that despite the Boil Water Advisory and extensive publicity, a small portion of the residents in Walkerton continued to expose themselves to the water through various routes, including brushing teeth with the water and occasionally drinking it.

Examination of well records from the PUC indicated that Wells 5 and 6 were supplying the town during the critical exposure time prior to onset of illness. Testing of water samples from the distribution system on 21 May and of water from Well 5 on 23 May demonstrated significant contamination with coliform and *E. coli* bacteria. Subsequent DNA analysis of these samples by polymerase chain reaction confirmed the presence of the O157, H7, and verotoxin genes, supporting the likelihood that *E. coli* O157:H7 had been present in these samples. Test results of Wells 6 and 7 on 23 May were negative for coliforms, including *E. coli* bacteria. Historic well reports and the 18 August 2000 interim report by Golders and Associates confirmed that Well 5 is subject to surface water contamination and elevated turbidity.

Environmental testing of 13 livestock farms within a four kilometre radius of the three wells identified human bacterial pathogens in animal manure on all but two farms. On nine farms, *Campylobacter* spp were identified, on two farms both *E. coli* O157:H7 and *Campylobacter* spp. were found; this included a farm adjacent to Well 5. The molecular subtyping and phage-typing of the *E. coli* O157:H7 and the *Campylobacter* spp. isolates from this farm were identical to those found in the majority of the human cases. While investigators could not prove the pathogens were present prior to the outbreak, the evidence suggests that the pathogens which entered Well 5 were likely to have originated from cattle manure on this farm. A simulation model of rainfall and the drainage pattern in the vicinity of Well 5 indicated that rain falling on the barnyard and adjacent fields would have drained toward Well 5.

A series of unfortunate circumstances occurred to cause an outbreak of this magnitude. These included heavy rains accompanied by flooding, *E. coli* O157:H7 and *Campylobacter* spp. present in the environment, a well subject to surface water contamination, and a water treatment system that may have been overwhelmed by increased turbidity. This situation emphasizes the importance of secure water sources and adequate water treatment in ensuring a safe water supply to a community. Bacterial
monitoring can only identify a contaminated source after the contamination has spread through the water system and put the public at risk.

The Walkerton outbreak calls into question the safety of ground water sources that may be under the influence of surface water, especially under flood conditions. Historically, ground water sources have been assumed to be secure and consequently treated with chlorination only. However, in light of this tragedy, this approach needs to be re-evaluated. Such an evaluation should take into account all current and future pressures on land use including human population density and agricultural activities.

Reference


Source:
*Bruce-Grey-Owen Sound Health Unit with the assistance of the Division of Enteric, Foodborne and Waterborne Disease, Bureau of Infectious Diseases, Centre for Infectious Disease Prevention and Control, Field Epidemiology Training Program, Centre for Surveillance Coordination, National Laboratory for Enteric Pathogens, Laboratory for Human and Animal Health, Population and Public Health Branch, Health Canada; Public Health Branch and Central Public Health Laboratory, Laboratories Branch, Ontario Ministry of Health and Long-Term Care.*
Summary of the Situation in Walkerton

Well 5 was contaminated during a heavy rainfall in May 2000. Bacteria from a farm manure pile (probably) entered the well through overland flow and/or through transport in groundwater after percolating down through the soil.

The overburden (the depth of soil above the aquifer) was very shallow at Well 5. The soil around Wells 5, 6 and 7 was also very permeable (see below) so bacterial contamination could easily percolate down to the aquifer.
Well 5 was an extremely shallow well and, when the pump was operating, water was drawn down from the surface water around the well. When the pump was not operating, natural springs occurred in the depression (standing water) around the well. In other words there was a direct connection between the surface water and the well as it pumped from the shallow aquifer. (see description below)

More detailed study of Well 5 showed that the aquifer was also very shallow and open to contamination (below)
Other problems emerged with other wells. Well 7 has an overflow device (a pipe connected to the well head) that allowed excess water to run out when the well was not operating. This was required since Well 7 is another artesian well (like Well 5) where the water flows even with the pump turned off. The "overflow" water entered a depressed land area (with some standing water). During a period of high rainfall, the area could have been flooded. If the well was turned on during that time, only a small plastic flap valve (below) prevented water "backing up" the pipe in to the well.
Coupled with these technical issues was the issue of management and reporting of contamination events. Reports from private laboratories that showed the presence of coliforms or *Escherichia coli* in the drinking water that were supplied to the Public Utilities Commission did not also have to be reported to the Ministry of the Environment or the Health Unit. The PUC was supposed to do that. This has been changed since the Walkerton contamination (see new Ministry reporting guidelines).

The Toronto Star called this the "broken loop" - (see below)
Then the chlorination plant either broke down and did not inject chlorine at the required level or it had been faulty for some time (this will emerge during the inquiry). Levels of chlorine in the drinking water are supposed to be at or above 0.5 ppm. Documented cases are in the log books for the wells where these criteria were not met. In addition, many reading over a long period of time were stated to be at either "0.5" or "0.7" ppm - an unlikely coincidence for all levels to be essentially identical over a long period of sampling.

Graphics from the Toronto Star