Walkerton Water and Complex Adaptive Systems

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About a year ago there was a major crisis about the water supply in Walkerton, a small Ontario Town in a farming area near Georgian Bay. In May 2000, there was a sudden outbreak of bloody diarrhea that affected up to half the town population of 5000, sent almost 900 people to get medical attention, hospitalized almost 100 of them and killed at least 7 people. It was shown that *Escherichia coli 0157:H7* (E.coli) contaminated the water supply and that a "boil water" directive was sent to the town's population only after people had become ill. There was a public outcry and a series of government responses, including a public inquiry into the circumstances surrounding these events.

In this brief account we suggest that many features of this case can be characterized in terms of complex adaptive systems. Such systems are increasingly being used as a way of understanding the nature of health, health systems and the development of health policy. (See our recent report: *Towards A new Perspective on Health Policy* which can be downloaded from our site: //www.healthandeverything.org) There is not space here to provide a full account of such systems. Instead we will use the Walkerton case as an example to illustrate some of their features.

Complex adaptive systems are composed of a number of relevant "subsystems. " In this case the people of the town of Walkerton, the water supply, the healthcare system, the animal husbandry in the surrounding area, the provincial regulatory mechanisms and so on can be seen as subsystems that interacted with each before, during and after the crisis. What was known about the situation, who knew it, when it was known varied in each of these subsystems and can help us understand more about the crisis. Finally we can consider the decisions that were taken in some of these subsystems at various stages of the crisis. The accompanying table contains a chronology and much of the background information.

Table 1 Walkerton Timeline (As Reported in the Press at the Time)

1995	Government closes down all four publicly run water-testing labs in province.
1997	Walkerton has always been responsible for its own water, but has no set methods for certifying labs, or legal requirement to test water or report results.
June 18, 1998	Walkerton town council addresses letter to Premier Harris—outlining concerns over cutbacks and closing of labs. Urged the "Government of Ontario maintain the Ministry of Energy and the Environment as the guardian of water quality, ensuring basic, healthy water standards for all Ontarians."
1999	Walkerton and two other local municipalities are amalgamated into Brockton.
Monday, May 15, 2000	Sample of water sent to private lab for testing.

Thursday, May 18, 2000	Lab sends report of lethal contamination to Walkerton Public Utilities Commission (PUC), read by Mr. Koebel, head of the PUC board.
Friday, May 19, 2000	Cases of bloody diarrhea reported to Medical Officer of Health, Dr. McQuiggie by Owen Sound area hospitals.
Sunday, May 21, 2000	After seeking a food based vector for the bacteria: Escherichia coli O157:H7, McQuiggie announces a boil water order.
Tuesday, May 23, 2000	Announcement made by PUC about contamination, confirmation of report on the 18th. Koebel had been doing "own testing".
May 31, 2000	Former Mayor of Walkerton, James Bolden visits local hospital with symptoms. He reports that while crowded, everything is running efficiently, including flights to London Health Sciences Centre, which now holds 11 patients (10 of them children).
by June 1st, 2000	Death Toll of 11 (7 confirmed—later 9), 784 received treatment for symptoms, 90 were hospitalized.
June 1, 2000	10 million litres of bottled water are stored in the town arena, some donated by an Australian company. In legislature the opposition parties demand the government make financial aid available to Walkerton and information about environmental protection to everyone. Durham, another county, shows some coliform contamination.
June 1, 2000	Premier Harris announces a public inquiry into the affair—not the proposed legislative inquiry, + police investigation. "I am a politician, and since I am ultimately responsible and accountable, it's hard to take it out of my hands," Premier Mike Harris.
June 6, 2000	Mr. Bruce Davidson sets up a coalition of Walkerton residents to ensure that their concerns are addressed by the public inquiry. They have independent counsel, and invite Howard Hampton, leader of the NDP, to the town. General feelings of distrust of all levels of government, in wake of daily revelations of who knew what and when.
June 12, 2000	Community of Walkerton rallies and many volunteers work to distribute donated supplies of diapers, water, bleach and juice at the community centre.
June 13, 2000	A new plan for increased privatization of public services is announced. Municipalities are told that unless they can demonstrate that the advantages of providing a given service publicly (Direct Services) "clearly outweigh" those of providing it privately (Alternative Service Delivery), they may not provide it.
June 15, 2000	Potential death toll upgraded to 14 as seven more cases go under coroner's investigation Claims are made that as many as half the population got sick.
June 16, 2000	Government reorganizes the ministry of the environment. Minister Dan Newman keeps job but deputy Stien Lal and other senior officials are moved.

Regulation of public health, especially water and food quality, is historically a government responsibility in Canada. It has become one of the infrastructural subsystems of the country - prerequisites for its normal operation. It is therefore also linked to other aspects of the infrastructure, such as, communication and transportation systems and the various social services systems, such as unemployment insurance and welfare benefits.

Some Questions about the Case

- Why was the water supply not safe?
- Why were people not warned when it was unsafe?
- What were some reactions to the crisis?
- What are relevant lessons for the future?

- **Why was the water supply not safe?**

  This is a good example of the kind of question that lends itself to a multiplicity of causal responses. It is clear that E.coli had contaminated one or more of the town wells. The measures used to chlorinate the water did not eliminate the E.coli. There was seepage of animal waste into the groundwater. There was a period of heavy rainfall in May that allowed contaminated rainwater to enter the wells. These answers are each correct and partial. One can, if one likes, add to them by describing particular techniques of animal waste management that resulted in the contamination, or the particular density of animal population, or the particular characteristics of soil composition, global warming, and so on. In complex systems the dynamic interaction between different subsystems can allow many small events in some subsystems to result in major events in others. There is not one linear chain of causes like a number of billiard balls hitting each other in sequence. Instead a multiplicity of events occur at roughly the same time in different places and together yield the result. In this case the coincidence of a series of small events such as those described above about the weather, the farms surrounding the town, the chlorination system, and the warning system resulted in tipping the health status of half the population of Walkerton from relatively healthy to ill. Many of these events are independent of each other, unlike a linear causal chain, where A causes B, B causes C, and so on. If it had not rained so heavily in May, there would still have been as much animal waste, and the chlorination system would have operated in the same way. Yet if it had not rained it is more than likely that the crisis would not have occurred.

  It is useful to distinguish between two sets of reactions to a crisis of this sort. On one account, if there were one clear cause of the crisis, then it would be possible and indeed critical to find the culprit and lay blame. At one time, we would have responded to the Walkerton events by hunting down and punishing someone in this way. On the other account, however, we recognize the multiple factors involved in maintaining the purity of the water. This leads us to speak not of an individual who is the cause, but of a *system* that is not functioning properly. We seek to find the flaws in the system and repair them.

  Attempts to simplify complex systems like the safe water supply can increase the risk of disasters, because the simplification process often ignores events that might stabilize or destabilize the system. In Walkerton, the provincial efforts to create a more streamlined system in some ways contributed to the increased risks in this way. The simplified reporting mechanism from the laboratory to the PUC without the requirement to report adverse test results elsewhere was a clear example of such an effect, the loss of a key check point or stabilizing agent. This case then, is an interesting example of a situation where the loss of a key checkpoint or stabilizing agent in a system may not become evident until several, apparently unrelated events have occurred.

- **Why were the people of Walkerton not warned about the unsafe water?**

  The laboratory that tested the water in Walkerton sent its test results to the Public Utilities Commission (PUC) of Walkerton. Its policy was that the test results were the property of its client, the PUC. Therefore it had no procedure for giving out the information to anyone else.

  The commissioner received the results, which declared that E.coli contaminated the water, but he was not convinced of the danger and so requested a retest. He wanted to wait for the new test results before declaring a public danger. In his position, it was difficult to say that the water was unsafe unless he had strong confirming evidence. In the mean time he did not communicate the test results to the public or to other groups. To some extent the commissioner was operating as if he were in a system with a simple causal structure. He believed that he should not act without being certain that the water was indeed contaminated. A new chlorination system had been installed. A new testing laboratory had been hired. He was not yet convinced of these results. Had he recognized some of the relationships to other subsystems he might not have been so dependent on only the results from one set of measures and conferred with others while re-testing. After the second test he in fact retreated to his home and was described as "a broken man" when he emerged five days later.

On the other hand, the Medical Officer of Health for the area was informed of some cases of bleeding diarrhea at the hospital in nearby Owen Sound and sought the cause in some type of E.coli contamination. He spent several days looking for the source in food and then failing to find one, without having access to any test results about water quality, issued a "boil water" order for Walkerton. He made a somewhat risky decision, with a level of uncertainty. He was, in fact, threatened for making it. His decision is more typical of ones that must be made in the context of complex systems.

How much evidence is needed for action in complex systems? In different "subsystems" there may be differing criteria of evidence and differing thresholds for decision making and action. The relative independence of some of the subsystems, and the lack of a clear causal chain for prediction and control makes it necessary to make decisions on the best available evidence, often with some degree of uncertainty. Reducing the uncertainty as much as possible is, of course, very important, but eliminating it completely is not possible.

- **What were some of the reactions to the crisis in Walkerton?**

Complex adaptive systems are *adaptive*. One of the side effects of complexity and the risk of destabilization—the occurrence of "messes", is that such systems will self-organize to evolve and regain stability. In Walkerton, the community organized itself in response to the crisis. Over 10,000,000 litres of clean water were brought in, from as far away as Australia. The community effort has been a major factor in recovering from the disaster, supporting those affected by it, and will remain a major factor in repairing and monitoring the water supply. This result in Walkerton mirrors the phenomenon of complex systems, in which chaotic, unstable states are transitional between states of stability. The tendency to come to a stable state - to create order out of messes is seen as a necessary by-product of such systems. Ilye Prigogine provides detailed accounts of this phenomenon in chemistry.

Other subsystems worked well in conjunction with each other. Support for ill people was readily available. The hospital in Owen Sound dealt with the influx of ill patients and those it could not handle were quickly transported to the Health Science Centre in London Ontario. The two-way interaction between public health issues like clean water and the health care system became more apparent. The Medical Officer of Health received reports from the hospital. Patients were tested for the dangerous E.coli. Advice was given and updated regularly about treatment for those affected.

A Question that Remains to be Answered

Bob McMurtry, an Assistant Deputy Minster at Health Canada asked, "Why did at least half the population of Walkerton not become ill as a result of contaminated water? Why did only 900 people seek medical care? Why were fewer than 100 people hospitalized? And why was the death rate as low as 7?"

These questions also can serve to point out some of the characteristics of these events that illustrate the complex nature of health. Illness as a result of exposure to E.coli is also a result of many particular conditions, including such factors as genetic susceptibility, general health status, age, social status, body weight, the amount of water consumed and so on. Such factors are not mutually exclusive, nor are they jointly exhaustive. The socioeconomic factors overlap with lifestyle ones. Genetic factors overlap with health status. The non-linear interactions among the factors render even this question complex. That is not to say that we cannot go a long way to answering it, by clarifying the boundaries as much as possible and recognizing the features of the system that impose limits to what can be learned.

Some Lessons from Walkerton

1. Self-organization arises from messes. It is a "free" by-product of complex adaptive systems.

2. We must learn to make decisions under conditions of uncertainty. There are limits to the amount of certainty that is possible in most subsystems. Recognition that decisions must be made with the best available data is sometimes difficult but necessary.

3. Reverting to rational planning often leads to decisions to streamline systems. But, when systems are complex, streamlining can increase risk.

Recommendations from Our Analysis

A peculiar characteristic of interventions in complex systems is that they often tend to be simple rather than complex. It is in simplistic mechanical views that complex solutions are often invoked, because in such systems there is a need for constant inspection, checking and tests for accountability. It is also worthwhile noting that if the system is indeed complex, increasing the mechanistic safeguards will not eliminate the risk of another water crisis. A relatively simple solution is to make sure that impending crises are nipped in the bud, by increasing the contacts between the players. Towns where the medical officer of health is in much closer contact with the people who manage the water supply will identify potential problems much sooner. There is little doubt that increased residential and industrial density and more farming intensity will create more opportunity for contamination of fresh water supplies. But other factors not so far considered may impact on such systems and good relationships among the players makes early warning more likely. Relying on purely mechanistic warning devices may very well result in new kinds of crises that are made worse by excessive reliance on instrumental mechanisms.