Understanding and Ensuring the Provision of Safe Drinking Water

Dr Steve E. Hrudey

Scientia

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Water is vital to sustaining human life and the contamination of drinking water can lead to disease and death. **Dr Steve E. Hrudey** from the University of Alberta's Division of Analytical & Environmental Toxicology has identified the challenges of providing safe drinking water and clarified misconceptions regarding threats to drinking water safety. Based on his research findings, he has provided critical recommendations for the provision of safe drinking water to protect public health.

The Importance of Safe Drinking Water

In 2010, the United Nations General Assembly recognised the human right to sufficient and safe water because it is essential to life. However, water is not naturally safe to drink. Over the past two centuries, the role of fully natural microbes (microscopic organisms such as bacteria, protozoa and viruses) in causing disease has been documented. Drinking water contaminated with microbial pathogens has been conclusively established to be the major cause of disease outbreaks arising from drinking water.

To be made safe, drinking water must be treated, managed and delivered to the point of use to reduce the risk of contamination to that of negligible likelihood. In some less developed countries, there is a lack of adequate drinking water services, resulting in contaminated drinking water which increases the risk of enteric diseases such as cholera, dysentery and polio. According to the World Health Organization, more than 800,000 people are estimated to die each year from diarrhoea caused by unsafe drinking water.

Affluent nations are fortunate to have the resources to provide safe drinking water and, therefore, experience fewer deaths associated with drinking water-borne diseases. However, despite having mostly advanced water management systems, drinking water disease outbreaks continue to occur in rich countries. Such outbreaks are clearly a preventable threat to public health.

Dr Steve E. Hrudey from the University of Alberta has examined the evidence surrounding drinking water disease outbreaks in affluent countries. In doing so, he has identified common underlying causes of such outbreaks, clarified common misconceptions about what safe drinking water means, and provided recommendations for ensuring the provision of safe drinking water.

Challenges to Providing Safe Drinking Water

In a report prepared for the Canadian Water Network, Dr Hrudey outlined the challenges that drinking water providers face in the effort to supply safe drinking water. Understanding what constitutes 'safe' drinking water is necessary to

minimise human health risk. However, what is deemed safe by health experts may not satisfy consumers' concept of safe drinking water. Drinking water providers must understand public expectations of safety to maintain consumer trust.

While the concepts of safety and risk can vary according to context and individual perception, Dr Hrudey adopts a pragmatic approach, defining safety as 'a level of risk that is so low that an accurately informed person need not worry about it.' Everyone who is born is certain to eventually die. What is not certain is when and from what causes. There is an enormous range of health risks that may shorten anyone's life, far too many to all be treated as equally important for any one person. 'Safe' drinking water poses a non-zero, but truly negligible risk to human health.

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E coli *bacteria*

Conventionally, safe drinking water has been pursued by setting guidelines for individual parameters, such as maximum levels of specific contaminants, on a precautionary basis to seek negligible heath risk over a lifetime of human consumption. While the simplification of the problem in this manner makes it seem more manageable, there are several challenges to this approach.

For example, a challenge for drinking water regulators arises when specific water quality monitoring yields detections approaching or exceeding these precautionary guideline values or where guideline values do not yet exist for particular contaminants. Additionally, some lower limits for contaminants have been based on an arbitrary detection limit rather than a well-informed health risk assessment. These may create public concern that is not based on credible evidence of health risk. Because many concerned individuals do not appreciate that detection of contaminants in water can and frequently does occur at levels far below what is necessary to cause adverse health effects, such trace detections can create unwarranted worry. Furthermore, monitoring water for a long list of contaminants, most of which are unlikely to pose a credible risk, can drain resources from operational issues of greater value to ensuring safe drinking water.

A key challenge to the provision of safe drinking water is a misunderstanding surrounding what threats are most important and in need of action. As Dr Hrudey explains, ‘the greatest risks to human health from public drinking water supplies in developed nations arise from microbial pathogens in faecal wastes from humans, livestock or wildfowl/wildlife.’ However, there is often higher public concern regarding the detection of chemical contaminants in drinking water at negligible concentrations and showing uncertain epidemiological evidence and inadequate relevant toxicological evidence. Though disinfection is a necessary process for removing pathogenic microbes from drinking water supplies, there is often opposition to disinfection driven by concerns about the resulting chemicals known as disinfection by-products.

In reality, as Dr Hrudey notes, recent fatal outbreaks caused by contamination of drinking water in affluent nations have been caused by microbial pathogens rather than chemicals. During and since his participation in the public Walkerton Inquiry (2000–2002), Dr Hrudey has focussed on studying the causes of drinking water outbreaks in developed countries to understand the common failures that lead to such outbreaks.

Past Mistakes and What They Teach Us

In May of 2000, heavy rainfall washed livestock manure from a nearby farm into a town well, contaminating the water supply to Walkerton, Ontario, Canada. Inadequate disinfection of the water resulted in an outbreak caused by the pathogenic *E. coli* O157:H7 bacterial strain and *Campylobacter* spp. that sickened over 2,000 individuals and led to seven deaths. The public Inquiry, led by Justice Dennis R. O’Connor, sought to establish the cause of the outbreak.

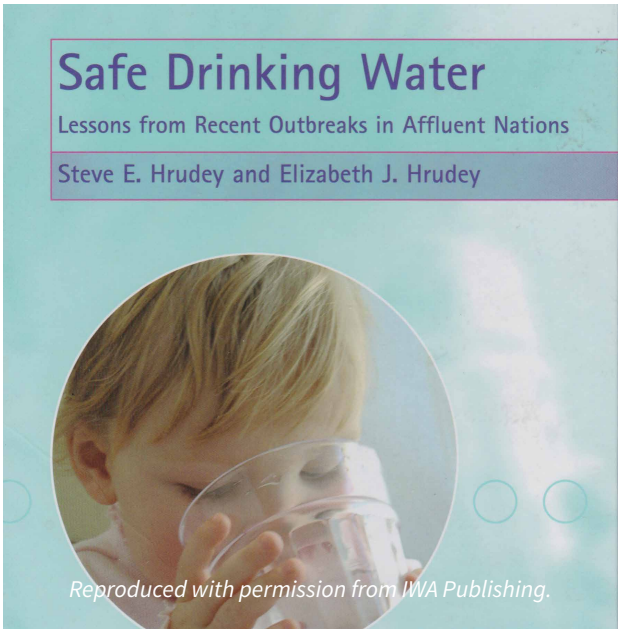
Since the Walkerton public health disaster, Dr Hrudey and his wife Elizabeth have published two international books documenting case studies of drinking water contamination failures. More than 30 major drinking-waterborne disease outbreaks in affluent countries have been reported in the scientific literature since Walkerton. The Hrudeys examined reports of these outbreaks and described the major recurring themes that caused such failures in a refereed journal article published in 2019.

First among the main themes identified were complacency, naivete and ignorance. Those responsible for delivering safe drinking water were found to have overlooked or misunderstood how prevalent faecal contamination of water sources is, as well as failing to recognise that livestock and wildlife host pathogens that can infect humans and that these hosts excrete these pathogens in their faeces.

Some of the cases that were reviewed involved simple failures such as not preventing human sewage discharges or livestock access from contaminating source waters. Therefore, despite knowledge afforded by decades of research into pathogens and their origins, well-characterised threats to drinking water safety had been overlooked in these outbreaks in affluent countries. As Dr Hrudey stated, ‘documenting case studies of drinking water outbreaks reveals that they are fundamentally a result of complacency and a failure to do what we know how to do.’

Another common issue identified by the Hrudeys was a failure to learn from experience. In these instances, individuals who were responsible for providing safe drinking water had not been informed about basic lessons from previous failures,

Credit. Steve Hrudey



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nor had they been adequately trained to recognise and avoid conditions that would allow preventable outbreaks to occur. This highlights a responsibility to communicate public health threats widely and effectively to all of those who are involved in providing safe drinking water.

Dr Hrudey has also found that fear of chlorination disinfection by-products has resulted in inadequate disinfection that contributed to waterborne disease outbreaks in many of the reported case studies. Although the human health risk of pathogenic microbes in drinking water has been well established in contrast to the uncertain risk from disinfection by-products that is generally negligible, there is a prevalent public belief that the chemicals pose a greater threat to public health than pathogens.

Recommendations for the Prevention of Drinking Water Disease Outbreaks

As a result of investigating recent drinking water outbreaks in affluent countries, Dr Hrudey concluded that such incidents were eminently preventable. This research identified the need for improved communication and education regarding previous outbreaks among all of those involved in providing drinking water. Dr Hrudey suggests that rather than relying primarily on compliance monitoring of contaminants, maintaining effective operations and implementing effective drinking water safety plans will enhance the capability of operational personnel to achieve better prevention of waterborne disease outbreaks. Drinking water safety plans must document a full understanding of one's water management system, the contaminant challenges it faces and the capabilities and limitations of the water safety barriers that are in place and are shown to be functional.

Drinking water safety plans must be living documents, fully understood by operators, used regularly and updated often. In accordance with this preventive risk management approach, Dr Hrudey suggests recognising a hierarchy of drinking water risks that can be adapted to local needs. Using this approach will ensure that the most critical risks receive the highest priority while less critical risks are given the less urgent level of attention they warrant. The first, most urgent category of risk denotes common, pervasive risks, highly certain to cause human disease, such as well-characterised microbial pathogens. Contaminants in this category require prompt and continuous effective action for any drinking water system.

The second, lesser priority risk category features reasonably certain but substantially less pervasive risks, such as lead, natural arsenic and excess fluoride, which should be identified where they occur and addressed as necessary. Common but comparatively uncertain and otherwise lesser risks in the third level of the hierarchy require a rational precautionary response. This third level includes disinfection by-products.

Finally, in the lowest risk category, site-specific contaminants with noteworthy toxic potential, such as pesticides, require localised plans appropriate to their risk. Such risk is typically low because this type of contaminant exposure through drinking water consumption is usually far too low to cause adverse health effects. This lowest risk category is also reserved for emerging contaminants that require research to characterise the nature of their risk.

Ultimately, Dr Hrudey advocates that the task of providing safe drinking water to the public requires collaboration and communication among all who are involved, utilising current knowledge regarding risks and employing effective preventive strategies. In doing so, the provision of safe drinking water can be ensured and risk to public health will be reduced.

Meet the researcher

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Dr Steve E. Hrudey obtained his PhD in Public Health Engineering in 1979 and later received his Higher Doctorate (DSc) in Environmental Health Sciences and Technology in 2002, both from the University of London. Currently, he is Professor Emeritus at the University of Alberta's Division of Analytical & Environmental Toxicology. Dr Hrudey's career in environmental and public health risk spans five decades, during which he has served on several expert panels dealing with high profile environmental health issues, published more than 190 peer-reviewed journal articles, and authored numerous books. Among other awards, Dr Hrudey was appointed a Member of the Order of Canada in 2019, received the Alberta Order of Excellence in 2017, and was recognised with a Queen Elizabeth II Diamond Jubilee Medal from the Royal Society of Canada in 2013. Dr Hrudey's research focusses on addressing misconceptions concerning public health and environmental risks with a major emphasis on safe drinking water.

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