

Drinking water and health research: a look to the future in the United States and globally

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ABSTRACT

Drinking water supplies continue to be a major source of human disease and death globally because many of them remain unsafe and vulnerable. Greater efforts are needed to address the key issues and questions which influence the provision of safe drinking water. Efforts are needed to re-evaluate and set new and better priorities for drinking water research and practice. More stakeholders need to be included in the processes of identifying key issues and setting priorities for safe drinking water. The overall approach to drinking water research and the provision of safe drinking water needs to become more rational and scientific, and become more visionary and anticipatory of the ever-present and emerging risks to drinking water safety. Collectively, we need to do a better job of making safe water available, accessible and affordable for all. One such approach to safe water for all is household water treatment and safe storage, which is being promoted globally by the World Health Organization and many other stakeholders and partners to reduce the global burden of waterborne disease.

Key words | drinking water, health, policy, pathogens, management, household water treatment

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INTRODUCTION AND BACKGROUND

The provision of safe drinking water in the United States has been a national concern since before the beginning of the 20th century (AWWA 1999; Baker 1948, 1981). Parallel developments in Europe, some of the most important technological advances in the provision of safe drinking water were adopted and developed as “best practice” in the United States more than a century ago. These advances include: (1) the use of slow sand and rapid granular media filters; (2) the use of chlorine as a disinfectant; (3) the understanding and practice of chemical coagulation and (4) the importance of choosing the best possible source of protected, clean water for a drinking water supply. The link between drinking water and waterborne disease was recognized early in the development and understanding of water, sanitation and hygiene in the United States (Committee on Indicators for Waterborne Pathogens 2004) and even earlier in Europe and other parts of the world (Barzilay *et al.* 1999; Hall & Dietrich 2000). The health

benefits of using improved water treatment practices were recognized early in the 20th century as the numbers of cases of typhoid fever and dysentery decreased dramatically. In 1914, the nation’s first drinking water quality standard, for bacteriological quality, was promulgated by the U.S. Treasury Department. These standards later became the basis for the US Public Health Service Drinking Water Standards and evolved into the current US EPA standards.

ISSUES AND QUESTIONS

Drinking water research and practice has focused mostly on water delivery infrastructure, “hardware,” treatment technology, specific contaminants, end product quality and poorly perceived or uncertain understanding of health risks. The historical preoccupation with these aspects of drinking water in the United States and globally deserves to be

questioned in this modern era of water and health. It is necessary to ask if this focus on technology, engineering practice, end-product quality and knee-jerk reactions to a few specific contaminants is really a rational basis for managing drinking water health risks. Is it the highest or main priority in the provision of safe water? Is the decision making process about drinking water research and practice focused on the most important issues to consumers and their communities? Furthermore, who decides what the issues and priorities are, and are all stakeholders represented or adequately represented in the decision-making processes? It must be asked if the process of setting priorities for drinking water research and good practice is "scientific", rational, anticipatory and visionary? Most importantly, is safe drinking water consistently available to everyone in the USA and in other countries?

Analysis and answers

Actually, the answers to all of these questions are: "No". The reality is we need to:

- address more of the key issues and questions which influence the provision of safe drinking water,
- re-evaluate and set new and better priorities for drinking water research and practice,
- include more stakeholders in the processes of identifying key issues and setting priorities,
- become more rational and scientific in the overall approach to drinking water research and the provision of safe drinking water,
- become more visionary and anticipatory of the risks to drinking water safety, and
- do a better job of making safe water available, accessible and affordable for all.

It is important to remind ourselves that safe and sufficient drinking water is a fundamental human need and a basic human right, as articulated by United Nations Secretary-General Kofi Annan on World Water Day, March 22, 2001. Providing technology and hardware, meeting end-product quality standards and reducing specific contaminants are not the only issues and the only goals. Drinking water is about people and their communities, not only in terms of water quality, quantity, affordability and

accessibility, but also their socio-cultural beliefs, practices, behaviors and perceptions. In addressing water and health, it is necessary to focus on the fact that water is a fundamental human right for all people, communities and societies, and that human behavior and the process of daily living is inextricably linked to drinking water. These aspects of drinking water and their implications for human health need to be addressed by appropriate research and practice. To address these aspects of drinking water and health, people and their communities must be at the table and their needs and sensibilities must be considered and served.

As is the case in many other countries, the American water supply industry has a dismal record of understanding and serving the water needs of all people. Many people and communities are un-served or under-served, and therefore, at risk. Some of the greatest risks are to those served by public water supplies of the community type which are very small, others which are of the non-transient, non-community type (almost 19,000 systems), such as schools which have their own water supply, and the transient non-community systems (>89,000 systems), such as those serving, rest areas and campgrounds. *Most public water supplies in the USA are small, poorly designed, poorly maintained and poorly managed. Furthermore, the smallest water supplies serve some of the poorest and least empowered Americans and communities and include a preponderance of economically disadvantaged small towns lacking an adequate economic base, with substantial populations of minorities, migrant and other seasonal workers, Native American territories and communities, and transients.* Similar problems with small water supplies, especially those serving economically disadvantaged minorities and other marginalized populations are found around the world. The quality of these water supplies and their human health risks are largely unknown and unstudied, but when they have been studied they are found to be poor and pose high human health risks. These water supplies are probably the most vulnerable in the United States and in many other countries as well, and they pose great health risks to consumers. They are the most vulnerable to contamination, have poor source waters and treatment facilities, lack the knowledge and skill for management and operations, and therefore, have the greatest potential to transmit waterborne disease.

Furthermore, about 1 in 6 Americans has a private, largely unregulated drinking water supply. Many private water supplies are rural and are used by poor, under-served minorities. Most rural drinking water supplies are from ground water sources, and many rural ground waters are contaminated with microbes and chemicals. Furthermore, most poor, minority rural water supplies are untreated or inadequately treated to control health-related contamination.

THE WAY FORWARD

A new paradigm is needed to improve drinking water research and practice. This paradigm embodies an overall conceptual framework which is holistic and risk-based and which assesses and manages drinking water quality from a health risk perspective. This paradigm has been developed and promoted by the World Health Organization through its new Guidelines for Drinking-water Quality (GDWQ), and is shown as a simple conceptual diagram (Figure 1) (WHO 2004). The Guidelines are scientific, evidenced-based and health based, and they embrace risk assessment and risk management as fundamental approaches to the provision of safe water for all. Key elements of this new and improved approach are the identification of health-based targets as the contaminants of greatest risk in a drinking water supply and the development of a system to manage these risks so that they are at acceptably low levels. The management system is comprehensive and addresses the water from its source to the consumer. The system is based on the development and use of a Water Safety

Plan(WSP) that is comprehensive but focuses on identification of critical control points in the water supply system and the vigilant and timely monitoring of these critical control points to maintain acceptable conditions and to take immediate corrective actions when conditions are unacceptable.

Research is critically needed to support this framework, including research on the identification and characterization of key waterborne pathogens as health-based targets, assessment of their risks and the development of risk management systems and WSPs that adequately address them.

Drinking water and health: what are the greatest risks?

Despite an American and other developed world pre-occupation with addressing a growing list of chemicals and their purported but mostly unproven health risks, the greatest risks of waterborne disease globally and in the United States are still from microbes (Blackburn *et al.* 2004; Fewtrell *et al.* 2005). Microbes cause illness and kill people, and contaminated drinking water contributes substantially to the global burden of waterborne infectious disease. With the exception of a few key chemicals (such as arsenic, lead and fluoride) the risks of illness and death from chemicals are low, mostly speculative and unproven. Simply, there is little epidemiological data to support significant health risks from chemicals.

In contrast, pathogenic microbes continue to be a major cause of waterborne disease globally, and they cause documented illness and death in the United States and worldwide. While efforts have been relatively successful in reducing the burden of water disease from some waterborne pathogens, many still pose a considerable risk to human health, and many of the responsible agents are either poorly understood or not even recognized. The ability to detect and monitor for pathogens in drinking water remains a challenge. None of the microbial indicators now used are capable of indicating the presence or predicting the risks of all pathogens, even using state-of-the-science detection methods.

Research is needed to better identify the important pathogens in water, to determine their health risks and to

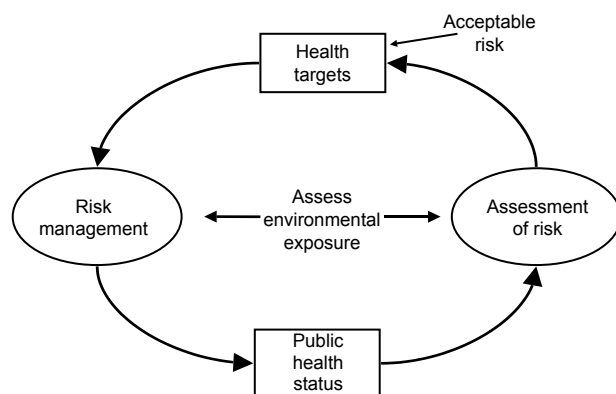


Figure 1 | World Health Organization conceptual framework for addressing and managing drinking water and health: simplistic format.

develop management methods which reduce their risks to acceptable levels. Despite all of the progress made in identifying drinking waterborne pathogens and reducing their disease risks, the risks probably still exist at high levels for some people and communities, and our efforts at risk management continue to be inadequate. Good estimates of national disease risks or burdens from waterborne pathogens are lacking in the United States and probably most other countries. However, it is likely that the risks are being underestimated. Until we focus on the most vulnerable water supplies and populations, this underestimation of microbial risks of waterborne disease will continue and likely become worse than it is now.

Drinking water and health and human behavior

In the United States, as in much of the developed Western world, the responsibility for providing drinking water and assuring its safety at the national, state, and community level is usually handled by institutions, authorities and other entities that are managed and run by governments, public works, private water companies or public-private ventures. At the other extreme are the private water supplies of homes and other small units that are the sole responsibility of the homeowner. In both cases there are major deficiencies which often lead to poor performance and excessive health risks. The public water supplies regulated by institutions often lack sufficient and scientifically sound input from individuals, communities and other entities which could inform the process and improve both decisions and performance. Almost completely lacking is a consideration of human behavior, attitudes, knowledge and practices about drinking water and health. At the other extreme, there is a lack of knowledge, communication and support that could inform individuals and improve performance in providing safe drinking water. The poorest and least served are also the least able to provide safe water for themselves. In both cases, there is a lack of understanding and appreciation of the social, behavioral, and cultural aspects of drinking water, and a failure to create and utilize social, political and other structures which provide systems to increase knowledge improve water science and technology and provide safer water for more people.

A good example of the human behavioral and social aspects of water and health is the place of water in the water and beverage market place. Consumption of commercial bottled water and other bottled beverages in the USA and many other countries around the world has reached new highs, with no end in sight. People in the United States willingly pay US\$1 per liter for bottled water or beverages. People in the United States and many other countries also willingly pay to have a water filter or other water treatment device in their home, either at point of entry or at point of use. People in the United States also complain when their water rates from a community piped supply increase a few percent annually, yet the price of the water is usually much less than US\$0.01 per liter. What determines the public's willingness to pay for water? How can the willingness to pay and the forces that drive it be understood and used to provide more people with safe water? The water supply industry and other stakeholders have not done a good job of marketing community drinking water. This may be because they have not paid adequate attention to their users as consumers who have social and behavioral attitudes which influence their decisions about the drinking water they use (Adamowicz *et al.* 2004; Laflamme & Vanderslice 2004).

Household water treatment and safe storage: is this a scientifically sound and practical way forward?

If people in the United States already use household, point-of-use water treatment can this social behavior be used to better provide safe water for all? The answer is probably yes. If piped or un piped water is either not safe or not perceived as safe why not treat all of it at point-of-use or entry? People can take charge of their own water and make efforts to ensure its safety (Chaudhuri & Sattar 1990; Sobsey 2002). If the people can learn how to assemble and use complex electronic equipment, such as computers, wireless networks, home entertainment systems and other household systems, why not create improved systems which make it possible for people to increase the likelihood they have safe water?

When and where is this needed or desirable? How can this process of implementation and empowerment be done and who should do it? How can the scientific community, the water industry and other stakeholders support this?

If public or private water supplies will never be sufficiently safe, is this an alternative to achieve safer water for more people and communities?

If the idea of household water treatment and storage seems too far-fetched, unscientific and unworkable to be a practical choice, consider this. The World Health Organization, in partnership with the global community for water, sanitation and health recently established an International Network to Promote Household Treatment and Safe Storage of Drinking Water (Quick *et al.* 1999; Mintz *et al.* 2001; Sobsey 2002; Sobsey *et al.* 2003; Thompson *et al.* 2003; Clasen & Mintz 2004; http://www.who.int/household_water/en/). Why did they do this? Because more than one billion people do not have access to safe water, either piped or unpiped. Many people die from or become ill from contaminated water which leads to waterborne disease. It is well documented that simple methods of water treatment and storage in the home will improve the microbial quality of water and reduce household waterborne disease (Sobsey 2002). The newly created Network is working hard on research, implementation, communication and advocacy to promote household treatment and safe storage. The results in all of these areas are impressive in just the first two years of its existence. If this approach is considered appropriate and effective in principle, why not embrace it, research it, implement it, and practice it for improved and safer drinking water in the United States and worldwide?

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