Waterborne Pathogens: Emerging Issues in Monitoring, Treatment and Control

Part 3

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This issue of *On Tap* is a continuation of the series of articles presented in the March and April issues, which coincided with my presentation at the WQA Aquatech USA conference and exhibition. This third and final article provides background information related to the WQA presentation, outlining some of the current challenges and future needs for providing a safe drinking water supply to consumers.

Parts one and two focused on the causes of waterborne disease, gaps in the US surveillance database and uncontrolled sources of drinking water contamination. They also focused on chronic health effects of waterborne pathogens and emerging concerns related to contamination sources, water quality monitoring and the need for a final barrier of protection. In this installment, we will focus on what microbes are expected to emerge in the future…and why.

Water contamination concerns

US EPA has set regulatory compliance levels for microbial water contamination at a level that is predicted to achieve at least no more than one in 10,000 infections per person per year. Meeting this goal is challenging due to treatment, distribution system, monitoring and population uncertainties. Often, the reliability of municipal treatment plant operations to provide consistent pathogen removal is impacted by unpredictable events. Treatment efficacy is a function of source-water quality, which is vulnerable to environmental insults related to climatic events, stormwater runoff and landwaste disposal from industrial, municipal or agricultural operations. Untreated groundwater supplies are another potential source of increased exposure to waterborne pathogens. Approximately 15 percent of Americans drink water from a private water supply where POU treatment provides the only barrier of protection.

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Disinfection byproducts continue to raise concern for consumers. Chlorine remains the most widely used chemical drinking water disinfectant in the world and has had a major impact on the elimination of waterborne plagues in developed regions. Moderate associations with chlorine DBPs (i.e., trihalomethanes or THMs), as well as birth defects and bladder cancer, prompt consumer demand for alternative treatments. Those, however, present additional uncertainties of efficacy and new byproducts that have not been extensively studied.

Another trend growing out of the desire to have a 'greener' society is decentralized wastewater treatment and reuse. Although 70 percent of household water use results in graywater that could be a valuable resource, the potential for the water to harbor harmful microbial and chemical contaminants provides additional risks to residents.

Monitoring needs

Despite the many advances in drinking water monitoring, real-time, in-line monitoring has not yet been achieved. New technologies are continuously being applied but are invariably stalled by the need to differentiate between viable and non-viable targets with high sensitivity and specificity. The gold standard for environmental monitoring and water treatment continues to be total coliform and fecal coliform indicator bacteria. Total coliforms are ubiquitous in the environment but provide a tool for monitoring overall water quality and disinfectant or treatment efficacy. Municipalities monitor for total coliforms at a rate dependent on the size of population being served, the type of influent water and the likelihood of source water contamination. Generally, no more than five percent of samples can test positive for total coliforms per month. If a water sample tests positive for total coliforms, repeat sampling and *E. coli* or fecal coliform, analysis must be conducted within 24 hours. A positive result is an initial red flag and triggers repeat sampling. A repeated positive indicates that the water has been contaminated with feces from either a human or animal source and thus a violation to the *National Primary Drinking Water Regulations* has occurred. The water supply should be additionally treated or removed from service until further treatment can be applied.

Routine total and fecal coliform indicator monitoring and follow-up treatment response have been partially responsible for the dramatic reduction of bacterial waterborne outbreaks in the US. With the reduction of bacterial disease transmission, however, viral and protozoan waterborne disease transmission became more apparent and researchers began to question the adequacy of bacterial indicators to predict the prevalence of other pathogens. Viruses and protozoa are regulated by the US EPA under a treatment technology approach; given that routine, direct monitoring for these pathogens is cost and technically prohibitive. Essentially, the municipal treatment train must be designed to remove 99.99 percent of viruses and 99.9 percent of protozoa. Given that bacterial indicators have different growth, transport and survival mechanisms than viruses and protozoa, treatment failures are not necessarily detected based on bacterial monitoring alone. According to the Centers for Disease Control and Prevention (CDC), the majority of all documented drinking water outbreaks recorded from 1971 to 2006 did not report exceeding the health-based regulatory standards, including *E. coli* in the 12 months prior to the outbreak.

'Pre-emergent' pathogens

Emerging or re-emerging pathogens are defined as those whose incidence has increased over the past 20 years or is expected to increase in the future. Commonly recognized emerging waterborne pathogens include *Cryptosporidium*, *Legionella*, and *Helicobacter pylori*. Resistance to conventional disinfectants and the ability to grow in the distribution system are key factors in the emergence of protozoan and bacterial pathogens, respectively. *Naegleria fowleri* (also known as the brain-eating amoeba) is a waterborne pathogen previously found in hot springs and warm surface water that is transmitted via entry into the nasal passage—it causes a fatal meningoencephalitis in humans. Twenty-three persons in the US have died from *N. fowleri* infections documented from 1995-2007, with six deaths in 2007 alone. Persistence in groundwater wells and growth potentials in storage tanks and distribution systems are newly recognized sources of the contaminant in drinking water where nasal transmission can occur from bathwater submersions, neti pots and other activities.

One might also consider 'pre-emergent' pathogens. This is a term I like to use to describe newly recognized microbes that are suspected to cause adverse human health outcomes or whose waterborne route is not yet proven. One example of a microbe to watch out for in the future is *Clostridium difficile*, a spore-forming bacterium resistant to conventional disinfectants, environmentally hardy and known to cause severe, and sometimes fatal, colon infections in humans. A long-time problem in hospitals, *C. difficile* is estimated to cause over 3.5 million infections per year at an economic burden of over three billion dollars (USD) in the US and is considered a more important hospital-transmitted pathogen than the well-publicized MRSA bacterium. Like MRSA, new *C. difficile* strains are being increasingly identified from the general population, acquired from community sources outside of hospitals. Transmission routes of community-acquired strains, however, have not been determined, but food and water are likely sources.

Various strains of adenoviruses are known to be transmitted via recreational and drinking water sources, causing eye and gastrointestinal infections. Adenoviruses are also known to be highly resistant to low-pressure ultraviolet light disinfectants commonly used to treat drinking water. A new strain of adenovirus (adeno-36) is further associated with obesity. Studies have found that 30 percent of obese persons test positive for adeno-36 compared to 11 percent of non-obese individuals. Laboratory rats infected with the virus exhibited significant weight gain, raising the question as to whether or not obesity could be a symptom of infectious disease.

Final-barrier essentials

In this series, we have examined some of the many unknowns associated with drinking water quality. While contamination events may be few and far between for most, they are unpredictable. Although most of the population is expected to experience a mild, self-limiting disease following exposure to waterborne pathogens, between 20-25 percent of the population is more susceptible; for some, the effects will be chronic. POU technologies provide additional protection to the general public and are especially beneficial to the immunocompromised. Exposure prevention will minimize acute disease and chronic sequelae, and reduce the economic burden of waterborne disease in both developed and developing regions. Therefore, POU water purification should be widely promoted as an essential final barrier in the multi-barrier approach for water treatment.

References

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