Water Quality Monitoring: How to Miss an Outbreak

By Kelly A. Reynolds, MSPH, PhD

Soon after the deadly Jack in the Box foodborne outbreak in 1992 that killed four people and sickened over 600, *E. coli* O157:H7 was identified as an important, harmful and emerging bacterial agent. More than 18 years later, additional deadly strains of *E. coli* continue to emerge. In a recent and controversial announcement, the US Department of Agriculture (USDA), in cooperation with the American Meat Institute, outlined a plan to routinely test for a total of seven disease-causing *E. coli* bacteria in food. Many of the same strains carried in food are also a concern in water, but policies for monitoring the microbial quality of food and water vary considerably. Water quality monitoring is primarily focused on detection of indicators of fecal pollution (i.e., non-pathogenic *E. coli*) and not specifically targeting the harmful *E. coli* strains that can make people sick. Is this a good approach or are we essentially practicing how to miss an outbreak?

Anatomy of an indicator

E. coli is naturally present in the human gut and the gut of nearly all warm-blooded animals. Our bodies have evolved with these bacteria, thought to aid in digestion, the production of vitamins and the general balance of microbial populations in the gut biome. Because *E. coli* is so closely linked to the presence of feces, it was identified as an indicator of fecal contamination and is now the most widely used target for determining the safety of drinking water and food supplies worldwide. A positive test for *E. coli* is interpreted as an indication that fecal contamination from humans or animals has occurred. Sources of such contamination in drinking water are municipal wastewater, septic systems, animal waste and stormwater runoff. Following a positive indicator test, the food or water is usually re-tested to confirm the result and taken out of circulation until the problem can be investigated or mitigated.

Historically, the water quality indicator monitoring approach was very effective at identifying vulnerable water supplies and provided data needed to identify and improve our wastewater disposal and treatment needs. As a result of guided treatment of drinking water and wastewater—improved by indicator monitoring for fecal pollution—the bacterial plagues of the past (i.e., typhoid, cholera, dysentery) continue to resolve. Drinking water outbreaks, however, continue to occur, even in developed regions with routine, regulated quality monitoring schemes. The question is, why?

Deadly versus harmless E. coli

Literally hundreds of *E. coli* serotypes have been identified. Perhaps the most familiar is *E. coli* O157:H7, which has caused numerous food and waterborne outbreaks. A commensal (i.e., harmless inhabitant) of the cow gut, there is no shortage of *E. coli* O157:H7 production on the planet. Ground beef and unpasteurized milk are the primary transmission routes of the pathogen. However, any water or food source subject to contamination from cattle or other linked environmental sources are vulnerable.

From the German term *ohne Hauche* meaning 'without film', the 'O' designation refers to characteristics of receptors on the bacterial cell wall, while the 'H' designation describes the organisms' flagella (a tail-like extension that bacteria often use like a propeller to increase motility). Specifically combined O and H characteristics can result in a highly proficient infecting agent—some with the ability to produce potent toxins. In the environment, bacteria are constantly interacting and interchanging genetic information. The result of these genetic exchanges can be new combinations of code that sometimes lead to newly emergent bacterial strains.

Various types of pathogenic *E. coli* include: enterotoxigenic *E. coli* (ETEC), enteropathogenic *E. coli* (EPEC), enteroinvasive *E. coli* (EIEC), enteroaggregative *E. coli* (EAEC) and diffusely adherent *E. coli* (DAEC). *E. coli* strains other than the O157 serotype cause an estimated 36,000 illnesses, 1,000 hospitalizations and 30 deaths in the United States each year. The food industry recognizes six primary non-O157 strains of concern, including *E. coli* O26, O45, O103, O111, O121 and O145. In 2011, a massive *E. coli* foodborne outbreak occurred in Germany that involved a new pathogenic O104:H4 strain (see *On Tap*, *WC&P* September 2011). This new strain, thought to be a combination of two previous strains, is more infectious, more toxic and more resistant to antibiotics than other pathogenic strains, with a 33-percent hospitalization rate, compared to 10 percent with other toxin-producing *E. coli*. The Germany outbreak, linked to sprouts, resulted in 36 fatalities among the 3,816 identified cases of illness.

Given the various types of *E. coli* present in the environment, food safety experts question whether a monitoring scheme that targets only non-pathogenic *E. coli* is a sound approach or if we are missing evidence of an outbreak. Water safety experts should be asking the same question.

Strategies of water quality monitoring

Approximately 15 percent of the documented *E. coli* outbreaks are due to drinking water exposures, with 61 percent of the outbreaks being linked to food. As the primary route of transmission, advances in *E. coli* monitoring and research are often from the food industry sector. In June 2012, the US Department of Agriculture announced a new strategy for directly monitoring the food supply for six additional *E. coli* strains (i.e., O26, O45, O103, O111, O121 and O145), which are believed to cause up to 80 percent of all non-O157 outbreaks. Criticism of this controversial (and expensive) monitoring scheme focuses on whether increased surveillance for multiple adulterants will result in a safer food supply.

We know that the non-pathogenic *E. coli* is not a good predictor of viral and protozoan hazards, given that bacteria have very different survival rates, disinfectant susceptibility rates and regrowth potentials. Thus, finding *E. coli* in drinking water may or may not mean you have a virus or protozoan present. Instead, you know there is feces likely present and thus, a potential concern that other pathogens may be present. A negative *E. coli* test really only means you do not have non-pathogenic *E. coli* or fecal contamination present. Theoretically, however, indicator *E. coli* would be detected if pathogenic *E. coli* were present and treatments capable of killing the non-pathogenic strain should be equally effective on the pathogenic strains. While plausible in theory, there is much we do not know about these newly emerging and deadly *E. coli* strains. Do they in fact persist when indicator bacteria don't? Thus, from a research perspective, it is time we increase our surveillance tools to monitor for not just indicators, but also targeted pathogens, including viruses, protozoa and bacteria.

Conclusions

The water industry promises to benefit from the new territory set by the USDA related to food quality monitoring. In 2013, the Food Safety and Inspection Service will launch a baseline study of the prevalence of non-O157 toxin-producing *E. coli* and O157:H7 and also *Salmonella* and indicator bacteria in meat carcasses. This data will help to inform how well indicator bacteria correlate with the presence of known pathogenic strains of bacteria. A similar study is also warranted for drinking water to determine if our current monitoring tools are effective at catching the next outbreak before it occurs.

References

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