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MICROBIOLOGICAL WATER POLLUTION

INTRODUCTION

Infectious disease is the subject of the recent annual report from the World Health Organization[1] that offers both hope for the future, stating "we stand on the threshold of a new era in which hundreds of millions of people will at last be safer from some of the world's most terrible diseases," while warning against "fatal complacency ... we stand at the brink of a global crisis in infectious diseases."

Worldwide, the WHO estimates that food- and water-borne infectious diseases caused 3 million deaths in 1995, and 80% of these were to children less than 5 years of age. Morris et al.[2] cited estimates of 99 million reported gastrointestinal infections in the U.S. each year, of which as many as one-third may involve exposure to waterborne pathogens. In the U.S., the annual costs (medical costs and lost productivity) of common intestinal infections were estimated to be $23 billion (food- and waterborne).[1]

A monthly review and summary of the scientific literature on human health effects and environmental pollutants, with an emphasis on pollutants of the Great Lakes ecosystem. Prepared under the direction of the Health Professionals Task Force of the International Joint Commission. This does not represent the official position of the International Joint Commission.

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Waterborne diseases may involve bacteria (such as *Shigella*, *Campylobacter* or *Salmonella*) or viruses (such as Norwalk or hepatitis A) but the public health spotlight is currently on protozoans. One protozoan, *Cryptosporidium*, has a life cycle that involves asexual reproduction within cells lining the intestinal tract, and a sexual reproduction phase that results in the production of oocysts that are released in the feces. Other protozoans that can also cause diarrheal diseases but are less common are *Cyclospora*, *Isospora* and microsporidia; their life cycles are similar, though the oocysts may not be infectious when passed in the feces.[3] Persons with compromised immune systems are especially susceptible to microbial infections; it is now estimated that the annual rate of cryptosporidial infection among AIDS patients may approach 5 to 10%.[4]

The source of microbiological pollution is often inadequately treated human sewage or runoff from animal husbandry facilities into streams or lakes; in addition, some microbial populations can increase in drinking water distribution systems. Other factors may also influence microbial levels, including: (1) wild animals are a reservoir for bacteria or protozoa that can infect humans; (2) variations in turbidity or water chemistry can affect bacterial densities; and (3) algal blooms may increase bacterial abundance.[5]

INFECTIOUS DISEASES IN GREAT LAKES REGION

Drinking-Water-related Outbreaks:

The largest recorded waterborne disease outbreak in North America occurred in March and April, 1993, in Milwaukee. More than 400,000 people developed gastrointestinal symptoms after exposure to *Cryptosporidium*-contaminated drinking water, and 4000 were hospitalized. In this outbreak, cryptosporodiosis is estimated to have contributed to an estimated 104 deaths.[2] In 1994, an outbreak of cryptosporidiosis claimed 37 lives in Las Vegas, Nevada. Particularly worrisome is the fact that the public water facility had tested for *Cryptosporidium* and not detected its presence.[6]

CDC researchers[7] summarized U.S. data on waterborne disease outbreaks from 1993-4, in which 22 outbreaks of infectious disease were reported from 17 states and 1 territory. Of these, 10 were found to be caused by *Cryptosporidium* or *Giardia*, while 7 were caused by bacterial contamination and 5 were of unknown origin. Two-thirds involved well-water, while 23% were linked to surface water supplies. These data probably underestimate the incidence of waterborne diseases; Frost et al.[8] estimate that only 10-33% of waterborne outbreaks are reported. Researchers in Ontario[9] found that county-wide hospitalization rates for gastroenteritis among children (less than 18 years of age) ranged from 78.2 per 100,000 per year (Middlesex County) to 1137.6 per 100,000 per year (Renfrew County), with an overall average of 411.1 per 100,000 per year.

Recreational Water Use-related outbreaks:

The CDC[7] also reports 14 infectious disease outbreaks associated with recreational water exposure, of which 10 were caused by *Cryptosporidium* and *Giardia* and 4 were caused by bacterial contamination. The four bacterial disease outbreaks were all associated with swimming in lakes, and 3 of the 4 Giardia-caused outbreaks were related to swimming in lakes or rivers. However, 5 of the 6 *Cryptosporidium* cases were linked to swimming in motel or community swimming pools. In addition to these outbreaks, there was one case of fatal ameobic meningoencephalitis reported in a child who had been swimming in both the Rio Grande River and a wastewater holding tank.[7]

The USEPA has collected data on beach closings from the U.S. counties bordering the Great Lakes, most of which were due to microbial contamination. There are 582 beaches and approximately half of them are monitored for water quality. Of those monitored, 51 (18%) were closed at least once in 1993, and 80 (29%) were closed in 1994. The total number of beaches closed during a season has ranged from 16 to 80 during the period 1980-1994, and there is no particular trend in the data.[10]

A randomized trial of the effects of seabathing on incidence of gastroenteritis[11] and non-enteric diseases[12] in adults was conducted in 4 resorts along the coast of the U.K. Over a 4-year period, 1216 adults were assigned to swim in coastal waters or to stay out of the water. Crude rates of gastroenteritis were significantly higher ($p=0.01$) in the seabathing group (14.8%) then the non-seabathing group (9.7%), and an apparent threshold level was found at 33 fecal streptococci/100 ml. Bathers had an excess risk of respiratory illness, compared to nonbathers, only when fecal streptococci exceeded 60 microorganisms per 100 ml (OR=3.92, 95% CI 1.59-9.49, $p=0.0014$). Risk of ear infections among bathers did not increase significantly until fecal coliform levels exceeded approximately 100 organisms/100 ml ($p<0.05$). When data from all study locations were grouped, an increased risk of eye infections was found in bathers (OR 2.06, 95% CI 1.01-4.25). No statistically significant trends were seen in skin ailments. The authors conclude that standards and guidelines would be more appropriately based on fecal streptococci than coliform bacteria.

ENVIRONMENTAL EXPOSURE SURVEYS

Data from a survey[13] of raw and treated water samples from 72 municipalities in Canada indicate that *Giardia* cysts are commonly found in raw water samples (21%), treated water samples (18.2%) and sewage samples (73%). However, *Cryptosporidium* oocysts were only found in 3.5% of treated water samples and 6.1% of raw sewage samples. The authors recommend an "action level" of 3 to 5 *Giardia* cysts per 100 liters drinking water for public health protection.

A study in two British Columbia watersheds[14] indicates that cattle ranches may serve as a source of protozoan contamination. Levels of *Giardia* cysts and *Cryptosporidium* oocysts were higher in samples taken downstream of cattle ranches, though the concentrations were lower in the watershed where cattle were commonly penned away from streams or lakes. In a survey conducted in the Yukon, Canada,[15] where there have been no reported outbreaks of waterborne diseases, 32% of pristine water samples were found to be contaminated with *Giardia* cysts, but no *Cryptosporidium* oocysts were found in the samples. Both cysts and oocysts were commonly found in treated and untreated sewage.

Juranek[4] cited findings of *Cryptosporidium* oocysts in over 65% of rivers and lakes tested throughout the U.S. Results of municipal water system sample analysis indicated that oocysts were present in tap water in over 27% of the communities evaluated. Paradoxically, in most outbreaks involving community drinking water supplies, the treatment facilities have been found to be in compliance with federal and state drinking water standards (the U.S. Safe Drinking Water Act standard requires that no more than 5% of drinking water samples collected in a given month can be positive for total coliform bacteria).[7] CDC researchers found "compliance with EPA's water-treatment standards (e.g. for turbidity and coliform counts) did not adequately protect against waterborne cryptosporidiosis." As a result, in May 1996, the U.S. EPA established a requirement that, beginning in 1997, public water supply facilities serving more than 100,000 monitor for *Cryptosporidium* oocysts.[6]

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OTHER ISSUES

Antibiotic Resistance: According to WHO, "two important human pathogens of animal origin, *E. coli* and *Salmonellae*, are today highly resistant to antibiotics in both industrialized and developing nations." Key components contributing to the rise in antimicrobial resistance are inappropriate uses of antibiotics and their overuse in animal husbandry operations. Uncontrolled or inappropriate use of antibiotic drugs in both industrialized and developing countries has contributed to the rapid development of resistance in pathogenic microbes. In addition, "enormous amounts" of antibiotics are used in the production of animal food; the WHO estimates that "more than half of the total production of antimicrobials is used in farm animals, either for disease prevention or growth production." Drug resistant bacteria in foods can be direct causes of disease in humans, or the resistance can be transferred to human pathogens.

Global Climate Change: Some researchers have argued that one cause of the resurgence of infectious diseases, particularly in developed countries, is global climate change.[16] The proposed mechanisms involve environmental changes or increased levels of pollutants that can bring disease-bearing wildlife into contact with humans, or cause algal blooms that may harbor or amplify microbial agents. As an example, Epstein[16] cites evidence associating increased growth of algae or plankton, which can harbor microbial organisms or spores, with expanding ranges of cholera bacteria.

CONCLUSION

In developing countries, inadequate sewage disposal and drinking water treatment facilities are primary causes of waterborne infectious disease. In industrialized nations, while treated drinking water is generally available to the entire population, organisms such as *Cryptosporidium* are challenging existing treatment technologies. Protecting water quality of the Great Lakes should include attention to microbial fauna and flora; outbreaks of diseases such as cryptosporidiosis remind us that we cannot overlook traditional public health concerns. Clearly, there is a need to reduce runoff of microbe-containing wastes into water supplies, while also strengthening water treatment programs and public health surveillance for infectious diseases.

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