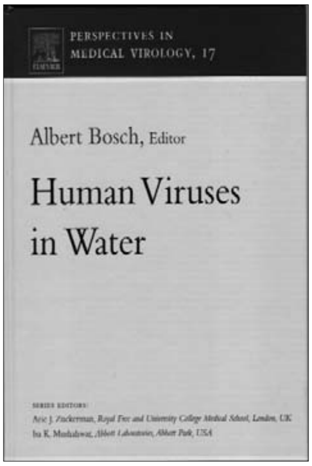

Human viruses in water (Perspectives in medical virology, vol. 17)

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2007, Elsevier, Amsterdam, Netherlands
299 pp, 17 × 24.5 cm
Price: € 78.95
ISBN: 978-0-444-52157-6

Around 1.1 billion people currently do not have access to an adequate water supply, and 2.4 billion people lack any type of access to decent sanitation facilities. About 2 million people die every year due to diarrheal diseases; most of these victims are children less than 5 years of age. The most affected are the populations of developing countries. Globally, the impact of waterborne viruses that cause gastroenteritis is difficult to assess because of the paucity of epidemiological data and the difficulty in detecting these viruses. *Human viruses in water* is an evaluation of the impact of viruses on water quality and, as such, offers information on new tools for the detection of viruses and risk assessment, the utility of water-quality indicators, environmental monitoring (virus occurrence and survival), and the regulations and guidelines that must be established to control water quality.

Viruses predominantly associated with waterborne transmission infect primarily the gastrointestinal tract; they cause gastroenteritis and are excreted through the feces. However, there are also viruses that cause other illnesses, such as hepatitis and polio. Gastroenteritis is a communicable disease characterized by fever, abdominal cramps, nausea, vomiting, diarrhea, and headache. After providing an overview of health-related water virology, the book goes on to discuss the numerous viruses found in the human intestinal tract (e.g., astrovirus; rotavirus; enteric adenoviruses; and the two genera of enteric caliciviruses, norovirus and sapporovirus; hepatitis A virus and hepatitis E virus; enterovirus) and the nature of the diseases they cause.

Developed countries normally have properly treated water and efficient sewage systems, such that viral gastroenteritis is predominantly self-limiting, with low mortality. Instead, most outbreaks of viral gastroenteritis are due to the consumption of contaminated vegetables, fruits, and other products, usually imported from regions where the responsible viruses are endemic. Shellfish, especially oysters and other mollusks, growing and harvested in polluted waters represents a potential threat both in developed and in developing countries. In fact, the food most commonly implicated in infectious outbreaks are oysters. Shellfish are normally consumed raw or undercooked, so there is no inactivation or killing of the enteric pathogens that may be present. While simple depuration processes are usually sufficient to remove bacteria, this is not the case for viruses, which persist in shellfish for extended periods of time (Chap. 10).

Numerous physical, chemical, and biological factors, such as temperature, light, pH, salts, and the presence of organic matter, influence the persistence of viruses in the environment; however, the most significant factor controlling virus survival is temperature. At nearly freezing temperatures, viruses can survive for many months. For example, at 8ºC in groundwater and 4ºC in surface water, viral inactivation is less than 0.01 $\log_{10}$ per day. Thus, an important characteristic of enteric viruses is their prolonged survival in the environment, and therefore their ability to continuously find new susceptible (human) hosts (Chap. 5).

Hazard analysis and critical control point (HACCP) programs have been applied to the quality assessment of drinking water in order to develop control measures and reduce risks to acceptable levels. The term "hazard" refers to a biological agent with the potential to cause adverse health effects. To manage water safety risks, it is important to identify the pathogen (viruses) as well as situations that may lead to waterborne illness, and to determine the magnitude of the impact that viruses have on human health. Such information allows rational decisions to be made about the need for increased management or regulation and guides the adoption of interventions to effectively reduce waterborne disease. Risk assessment consists of four steps: (1) Hazard identification (types of pathogens and description of the illnesses they cause, the need for hospitalization, and mortality); (2) exposure assessment or dose-response (quantitative relationship between dose and outcome, e.g., ID_{50}, the number of microorganisms required to initiate infection in 50% of the exposed population); (3) hazard characterization (prevalence, concentrations, distribution in time and space in water or food consumed); and (4) risk characterization (the quantitative likelihood of potential adverse health outcome based on the above) (Chaps. 7 and 8).

The era of pathogen discovery is clearly not over, and all of the recent microbiological advances must be employed to improve our understanding of the transmission of diseases through water. Nonetheless, the detection of viruses in water and other environmental samples poses particular challenges and often cannot be achieved by routine screening methods. Viruses in water are usually present in concentrations too low for detection by direct analysis, so a multi-stage process, involving concentration of a potential virus-containing sample, is almost always required. This concentrate is inoculated into cell cultures, which facilitates identification of the virus, or it can by analyzed by molecular biology procedures, such as the polymerase chain reaction (Chaps. 9 and 13). The complexity of these approaches on a large-scale basis underlines the importance of indirect indicators to assess water quality. Bacteriophages of enteric bacteria, such as coliphages or phages infecting *Bacteroides fragilis*, have been proposed as viral indicators. Bacteriophages persist longer than conventional bacterial indicators in aquatic environments and their persistence reflects that of human enteric viruses (Chap. 11).

The regulatory requirements for virus reduction are usually 99.99% reduction from a water source. Removal processes are normally implemented at the beginning of water treatment, whereas disinfection is a follow-up treatment used to inactivate viruses that have "escaped" the removal process. Viruses are normally removed by coagulation, sedimentation, flocculation, and filtration. Inactivation processes render viruses non-infectious to host cells even if they remain present in the treated water. The main inactivation methods used in water treatment include disinfection with chlorine, chloramines, or chloride dioxide, sometimes preceded by ozonation or UV irradiation (Chap. 6).

As discussed in the book's closing chapters, monitoring of human viruses in water must be done according to internationally accepted standards. It is essential that the methods and techniques undertaken by a laboratory are fit for their intended use and appropriately documented according to standard operating procedures. It is also necessary to adequately validate new methods and to compare them with previously established ones. In addition, monitoring of water quality should be regulated at the national level to insure uniform standards. This approach must mandate regular sampling of water sources. Such data provide the basis of water treatment and can be employed to generate predictive models of the potential risks to public health.

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