WATER AND HEALTH

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Contents

Summary

The global impact of water-related diseases may be compared to that of jumbo jet airliners each carrying 400 children and 100 adults crashing with no survivors every thirty minutes around the clock. This calculation is based on World Health Organization (WHO) and World Bank estimates that some 50,000 people die each day in the world from water-related diseases. This refers to deaths only, and excludes suffering and devastating socio-economic implications. The comparison to aircraft crashes does not only illustrate the public health impact, but also reflects perceptions and priorities. When an aircraft crashes it is headline news all over the world, and every effort is made to disclose the reasons for the accident and to prevent a repetition. On the other hand, the 50,000 people that die every day from water-related diseases, and the millions more that suffer other implications, are hardly more than a statistic in records of agencies such as the WHO, the World Bank, and UNESCO. This seems to contradict public health and political aspirations regarding human rights and the access to safe water for all.

Despite major progress in water supply and sanitation technology, and massive investments in efforts to control water-related diseases, the overall global incidence and impact of the diseases would not appear to have decreased. This is due to a number of developments such as:

- Increase in the global population of humans and domestic animals.
- Frequent and rapid movement of people and goods all over the world.
- Deteriorating financial capabilities of many communities and countries.
- Climatic changes.
- Emerging new pathogens and re-emerging pathogens.
- Selection for pathogens resistant to water treatment and disinfection processes.
- Escalating numbers of people with increased susceptibility to waterborne diseases.

Due to the above developments the world has become so small that it is often referred to as the “global village.” This implies that many natural resources must be considered as common good. Water is a typical example of a commodity that knows no political or international boundaries. Earth has a restricted supply of water on which all life depends. Growing awareness of this situation stimulates research and the formulation of strategies to promote the sustainable utilization of the precious resources. The same applies to water-related diseases, which can no longer be regarded as “other people’s problems.” They have become “our water-related diseases.” Sustainable utilization of

water and the control of related diseases do, therefore, require an orchestrated international approach.

Remarkably efficient practices for the removal and treatment of wastes, protection of natural water resources, and the supply of safe water, have been established to benefit the well-being of many people, particularly over the past 100 years. However, for a number of reasons a high percentage of people remain without access to safe water and sanitation. Endeavors to address these challenges are complicated by the reasons listed above.

The way forward clearly calls for coordinated global efforts with optimal utilization of expertise and resources to find solutions for a common challenge. Sound progress is being made. Sophisticated modern technology including molecular and genetic techniques, is being used to identify waterborne pathogens and to study their behavior in water resources and treatment processes. Comprehensive epidemiological studies reveal the secrets of waterborne transmission of pathogens and disclose weaknesses that can be exploited to disrupt the cycle of transmission. At the same time engineers and chemists work on new techniques for the efficient and cost effective protection of water resources and the removal of pathogens from water.

Current progress includes assessment of the burden of waterborne diseases, which is essential to calculate resources justifiably invested in control strategies. This work is supplemented by advanced studies on risks of infection constituted by various water supplies. The results are used to define fundamentally important issues such as acceptable risks of infection, realistic and practical quality specifications, and risk management programs. New approaches to quality control include replacement of specifications based on end-point testing, by hazard assessment, and control at critical point (HACCP) strategies. Efforts along these lines are driven by the WHO in collaboration with a variety of other role players. Some of them focus on technical aspects of sanitation and water supply, others on education and training, and others on the optimal investment of restricted financial resources. The overall challenge remains the sustainable utilization of restricted global water resources in order to sustain life on earth.

1. Introduction

The theme for international World Health Day 1997 (7 April) was “Emerging Infectious Diseases, Global Alert – Global Response.” WHO Director-General Dr Hiroshi Nakajima pointed out that the theme was chosen “to send a clear and urgent message: infectious diseases are still with us; we must improve their detection and prevention, and never give up searching for better ways to prevent, alleviate and cure them.” His speech included statements such as:

During the 1990s, emerging infectious diseases have become a major public health concern. Some thirty new and highly infectious diseases have been recorded in the last twenty years. The globalization of trade, the mass movement internationally of huge numbers of people, either as tourists, business travelers, migrants or refugees, the

uncontrolled growth of mega-cities, and changes in ecology and climate are creating new opportunities for the re-emergence and spread of infections.

Water is closely associated with the spread of many of the diseases referred to. Infections are predominately caused by contaminated drinking-water supplies and shortcomings in sanitation and personal hygiene. Related means of transmission include direct or indirect exposure to contaminated water in a wide variety of recreational activities, the consumption of food, such as shellfish, harvested from polluted waters, and crops irrigated with polluted water. Estimates of the morbidity and mortality associated with unsafe water supplies and inadequate sanitation differ because reliable data are not available due to the many variables involved. These include the virtual absence of information on the cause of morbidity and mortality in many populations. Other complicating factors include secondary transmission of infections originally contracted from water, and the many sub-clinical infections contracted from water that only cause clinical disease when transmitted to susceptible individuals by means not associated with water.

According to one report every year approximately 2.2 million people die from water-related diseases and unclean domestic environments. Other estimates are substantially higher. In 1997 a WHO Ad Hoc Committee on Health Research estimated that the lack of safe water supply and adequate means of excreta disposal was responsible for 5.3 percent of all deaths globally, only slightly less than the 6.0 percent attributed to tobacco use, and the 5.8 percent attributed to hypertension.

Extreme examples of waterborne disease outbreaks include the 300,000 cases of hepatitis A and 25,000 cases of viral gastroenteritis in Shanghai caused in 1988 by shellfish harvested from a sewage-polluted estuary. In 1991 an outbreak with 79,000 cases of hepatitis E in Kanpur was ascribed to polluted drinking-water. The outbreak in 1993 with some 403,000 cases of *Cryptosporidium* diarrhea associated with a conventional drinking-water supply in Milwaukee illustrates the well-established fact that waterborne diseases are not restricted to poor communities living under conditions of low hygiene, inadequate sanitation, and unsafe domestic water supplies. Waterborne diseases also constitute major health risks in industrialized countries with water supplies treated according to internationally accepted specifications.

The water industry has a long history of research and development aimed at supplying safe water and controlling water-related diseases. In modern times certain principles for the treatment and disinfection of water became established. However, evidence is accumulating that drinking-water supplies that have been treated by processes generally accepted as sufficient and meeting conventional guidelines for bacterial indicators of fecal pollution, may play a meaningful role in the transmission of pathogens (see section 6.1).

Since worldwide there would not seem to be a meaningful decline in the impact of water-related diseases, research on fail-safe treatment technology and reliable quality monitoring continues. The challenges to accomplish these goals increase in complexity as populations of humans and domestic animals increase with concomitant demand for potable water, and pollution of limited water resources escalates. Special efforts are

required to control waterborne diseases in developing communities and countries, which are most vulnerable to these diseases.

2. Water-Related Diseases

The term "water-related diseases" is generally understood to include illnesses resulting from both direct and indirect exposure to water, whether by consumption or by skin exposure during bathing or recreational water use. Water-related disease may be classified in terms of the agents responsible and the types of water exposure, but for surveillance purposes, the classification system must also include the probability of association with water, since multifactorial aetiology is involved in most, if not all, of the water-related diseases. In public health terms, the classification system should also include factors related to intervention, such as the type of water treatment or sanitation measures required to remove the disease-causing factors. Host factors are relevant to water-related disease transmission, since many of the agents more severely affect individuals who are malnourished or already suffer from other disease, including diseases associated with immune deficiency. The inherent relationship between water and food also complicates water-related disease classification: in many surveillance systems, statistics on water-related diseases tend to be integrated in data on gastroenteritis or on food poisoning.

Historically, water-related disease has been a major health problem for both developed and developing countries. Its priority as a surveillance issue has fallen partly as a result of improved water and sanitation in industrialized and northern countries of the world, associated with lower morbidity and mortality from diseases such as cholera and typhoid fever. Food-related disease surveillance has overtaken it in importance and in some countries water-related disease is classified under food poisoning or gastrointestinal infection, further diminishing its importance in surveillance statistics. The emphasis on the infections affecting the gastrointestinal system is appropriate in terms of numbers of cases, since gastrointestinal infection is the commonest water-related illness, worldwide. However, a gastrointestinal-based classification ignores respiratory infections linked to contaminated water, such as legionellosis, and also skin or systemic disorders. Non-infectious waterborne disease is increasingly recognized as a public health concern, requiring different types and complexity of surveillance from the traditional systems based on microbiological agents.
The classification of diseases associated with water is based on three essential components (see *Classification of water-related diseases*):

- The pathogens and other agents involved in water-related disease.
- The type of water exposure.
- The level of probability of a water cause.

Host factors, such as nutritional status, are important in terms of the priority and detail required for surveillance systems in countries with high levels of malnutrition, immune deficiency, or significant mortality from waterborne pathogens.

Water-related disease is defined as any significant or widespread adverse effects on human health, such as death, disability, illness, or disorders, caused directly or

indirectly by the condition, or changes in the quantity or quality of any water. The causes of water-related disease include micro-organisms, parasites, toxins, and hazardous chemical compounds. “Water associated disease” covers the wide range of diseases in which water plays a part, such as legionnaires’ disease, as well as diseases related to lack of water for washing and hygiene. The advantage of the term “water-related disease” is that it includes both waterborne and water-associated ill health, although diseases with an indirect association and another major mode of spread are usually excluded from specific surveillance systems. An example of an indirectly related disease is trachoma. The predominant mode of spread is via poor hygiene and flies thriving in conditions of poor sanitation. Clean water for hygiene is an important element in prevention, but the disease is not otherwise water-related. Such diseases used to be known as “water-washed,” referring to the role of clean water in removing the agents, but the term is no longer widely used: “water-hygiene diseases” is an alternative.

Based on the above considerations, water-related diseases are classified in the following seven categories:

- *Waterborne microbiological disease.* Disease related to the consumption of water containing pathogens usually due to human or animal fecal contamination of water.
- *Waterborne chemical disease.* Disease related to consumption of water containing hazardous chemical compounds.
- *Water hygiene disease.* Disease of which the incidence, prevalence, or severity can be reduced by using safe (clean) water to improve personal and domestic hygiene.
- *Water contact disease.* Disease caused by skin contact with water that contains pathogenic micro-organisms or hazardous chemical compounds.
- *Water vector habitat disease.* Disease caused by pathogens the vectors of which live all or part of their lives in or adjacent to a water habitat.
- *Excreta disposal disease.* Disease related to unsanitary disposal of human feces and urine.
- *Water aerosol disease.* Disease related to the inhalation of aerosols that contain pathogenic micro-organisms.

These categories can be divided into a number of subcategories, including subcategories related to features such as the duration of exposure (acute/prolonged).

2.1. Pathogenic micro-organisms

Waterborne diseases are typically caused by enteric pathogens that belong to the group of organisms basically transmitted by the fecal–oral route. In other words, they are mainly excreted in feces by infected individuals, and ingested by others in the form of fecally contaminated water or food. Some of the pathogens may be of animal origin. Some may also be transmitted by personal contact, droplet transfer, or inhalation of contaminated aerosols. Water may also play a role in the transmission of pathogens that are not of fecal origin. These include opportunistic pathogens that are members of the normal flora of the external human body. Some of these pathogens are released into

water from wounds, lesions, or ulcers. Some opportunistic pathogens are natural inhabitants of certain water environments.

Assessment of the public health impact of waterborne diseases is complicated by factors such as:

- Many infections are not readily diagnosed, and detection of the aetiological agents in water is even more difficult. Waterborne transmission and assessment of the public health impact are, therefore, difficult to prove. The same applies to infections that have long incubation periods or manifest in long-term effects. For instance, viruses are estimated to play a role in about 20 percent of cancer cases, and well-known oncogenic viruses such as papilloma, polyoma, and hepatitis B are excreted in urine. However, epidemiological association of the diseases with waterborne transmission would be difficult. Proving the waterborne transmission of pathogens is as difficult as proving the reverse, in other words, proving where people with infectious diseases got their infections from. These conclusions are supported by data on complications and manifestations of infections by coxsackie- and other enteroviruses that are not readily associated with waterborne transmission.
- Many waterborne infections, particularly viral infections in children, do not cause clinical disease. However, the pathogens are replicated and excreted by the infected individuals, which constitutes a risk of infection to others.
- The impact of infectious waterborne diseases is aggravated by infected individuals who transmit the pathogens to other people by routes such as personal contact. Secondary and even tertiary transmission of waterborne diseases has been confirmed epidemiologically. Obviously, it is difficult to detect this indirect transmission of pathogens by water, and it becomes virtually impossible when the primary infection contracted from water was sub-clinical.
- The prevalence of different waterborne pathogens changes as selective pressures in various communities and parts of the world change. For instance, in the United States the transmission of most bacterial pathogens by water decreased extensively in recent years due to more efficient treatment of water. However, the relative role of viruses, protozoan parasites, and some bacteria, such as *Escherichia coli* O157:H7, has increased due to factors like higher resistance to treatment processes. *Cryptosporidium parvum* was not generally accepted as a human pathogen until about 1976; it was associated with waterborne transmission for the first time in 1985; and in 1993 it caused the Milwaukee cryptosporidiosis outbreak which is the largest waterborne disease outbreak on record.
- The incidence and prevalence of waterborne pathogens is subject to geographical factors. Most of the pathogens are distributed worldwide, but outbreaks of some, for instance cholera and hepatitis E, tend to be regional. Dracunculiasis is restricted to rural areas in India and Pakistan, and Nigeria and certain other sub-Saharan countries.
- Individuals in various communities are not equally susceptible to water-related infections. Persons with increased risk of infection as well as severity of disease include the very young and the elderly, pregnant women, undernourished individuals, and patients with compromised immunity due to diseases such as

AIDS and medical interventions, as in the case of organ transplant and cancer patients. Others include those predisposed to illnesses like diabetes, and those with a chemical dependency as in alcoholism. In the United States individuals at increased risk of waterborne diseases constituted almost 20 percent of the total population in 1993. This percentage is growing, and in some other countries, notably the developing world, the percentage may be considerably higher.

One implication of the above is that data on the incidence of water-related disease, the importance of various pathogens potentially transmissible by water, and the risk of infection, cannot be extrapolated from one part of the world, country, or community to another. The wide variety of pathogens that may be transmitted by water has been reviewed in detail (see *Classification of waterborne diseases* and *new and emerging waterborne infectious diseases*).

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Biographical Sketch

Wilhelm Otto Karl Grabow was Professor and Head of the Department of Virology, Faculty of Medicine, University of Pretoria, South Africa. He has been engaged in research, training, and education on health-related water microbiology for more than thirty years. He is the author of more than 150 publications and 200 conference presentations.

Positions held in international scientific activities:

- Founder Chairman of the Specialist Group on Health-Related Water Microbiology of the International Water Association.
- Member of the Governing Board and Strategic Council, and Chairman of the Conference Programme Committee, of the International Water Association.
- Chairman of the South African National Committee of the International Union of Microbiological Sciences.
- Member of a Task Group for Water Quality Guidelines of the World Health Organization.
- Chairman of a Sub-Committee, and Member of various other Sub-Committees and Working Groups, of the International Organization for Standardization.
- Invited by the International Council of Scientific Unions to participate in the International Conference on an Agenda of Science for Environment and Development into the 21st Century (ASCEND 21) in 1991 in Vienna, Austria.
- Invited by the American Society for Microbiology to serve on a Task Group for the formulation of a document on Global Issues in Microbiological Water Quality for the Next Century.
- Member of the Editorial Board of *Standard Methods for the Examination of Water and Wastewater* of the American Public Health Association.
- Member of the Editorial Board of four international scientific journals.