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<th><strong>Title</strong></th>
<th>Health and sanitation</th>
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Health and Sanitation

By

Wayne Harrington
HEALTH AND SANITATION

1.0 INTRODUCTION

Providing safe water and managing waste water have had a central role in reducing the incidence of many waterborne or water-related communicable diseases. One of the major achievements of the past 150 years is the extent to which the diseases associated with water have become of very minor significance in the mortality and morbidity of most developed countries and of some developing countries (especially for richer groups living in major cities). But the diseases associated with contaminated water remain among the most serious public health problems for much of the world’s population. Water shortages are imposing serious constraints on the expansion of food production and industry, and the provision of adequate sanitation in many countries or regions within countries. Countries or regions with relatively low per capita levels of freshwater withdrawal will find it difficult to meet increasing demands for fresh water from growing populations with growing per capita levels of consumption and from agriculture and industry.

There are three crucial concerns in the relationship between water and health. The first is how constraints faced by water-poor countries will impact on human activities. The second is how to maintain acceptable water quality in the face of growing demand. The third is the direct link between health and water, especially concerning diseases associated with insufficient and poor-quality water and with inadequate provision for the disposal of waste water.

2.0 WATER AND WATER USE

Over the last three centuries the growth in the volume of water withdrawn from freshwater sources for human use has been much more rapid than the growth in population. Water use has increased more than 35 times (1), whereas human population has only increased sevenfold.

Current water use levels are stabilizing in many developed countries but still growing in most developing ones. They are likely to continue to grow rapidly into the future if developing countries are to reach the per capita annual water use as that in developed countries. Many of the wealthiest industrialized countries use over 500 cubic meters per person per year, a few use over 1 000, and the USA uses over 2 000. Some developing countries also are among the world’s highest per capita water users, for instance Argentina, Chile, Egypt, Iraq, and Pakistan. However many of the poorest countries use only between 20 and 50 cubic meter per person per year (2).

Most freshwater is used is for agriculture. Irrigated agriculture accounts for about 70% of the total world use. Sustaining food production demands sustainable water supplies. Demands on water for food production will have to rise if food production is to keep pace with population growth and with changes in dietary preferences that imply more water-intensive food production. Since 1950, the area under irrigation has nearly tripled; one-third of the world’s food is grown on irrigated lands, which comprise only 18% of total cropland. (3).

The industrial sector, including the energy sector, uses between 40% and 80% in developed countries and only a few percent in most developing countries.
Domestic and municipal water needs account for only about 7% of total water used, although the proportion is higher in most developed countries. Estimates suggest that domestic and municipal water needs will account for 16% of water use in Europe by the year 2000 (4).

3.0 COMMUNICABLE DISEASES ASSOCIATED WITH WATER

Most of the disease agents that contaminate water and food are biological and come from animal or human faeces. They include bacteria, viruses, protozoa, and helminths and are ingested with water or food or conveyed to the mouth by contaminated fingers. Once ingested, most of them multiply in the alimentary tract and are excreted with the faeces. Without proper sanitation, they find their way into other water bodies, from where they can again infect other people. Many of the organisms in this enteric group can survive for a long time outside the human body. They can thus survive in human sewage and occasionally in the soil and be transmitted to water and foodstuffs. The more resistant organisms may be transmitted mechanically by flies breeding in accumulations of domestic waste around settlements.

Most diseases associated with water are communicable. They are usually classified according to the nature of the pathogen, but in considering health and the environment, it is more convenient to classify them into four categories according to the various aspects of the environment that human intervention can alter (5): waterborne, water-washed, water-based, and water-related (6). A fifth category emerging in developed countries could be called water-dispersed.

- Waterborne diseases - these arise from the contamination of water by human or animal faeces or urine infected by pathogenic viruses or bacteria, which are directly transmitted when the water is drunk or used in the preparation of food. Cholera and typhoid are the classic examples (although infection is not only through ingestion of contaminated water; direct transmission through the faecal-oral cycle and food contamination also take place). Other diseases such as leptospirosis may be acquired through contact of abraded skin with infected water.

Diseases arising from the ingestion of pathogens in contaminated water or food have the greatest health impact worldwide. The pathogens are often symptomless in carrier individuals and sometimes in animals not susceptible to them, and they can survive for varying periods of time in water and be swallowed with it. They include those at the origin of classic epidemics - cholera, dysentery, and typhoid fever - and a considerable variety of other microorganisms, including protozoa (e.g., amoebae) and viruses (e.g., hepatitis A). They may be found in untreated water contaminated by human and animal excreta or remains, or in water handled unhygienically after treatment, as often happens in water shortages for hydrogeological or economic reasons. In these latter situations, contamination of food is as likely as contamination of water and it becomes difficult to attribute responsibility to this or that pathway, though the primary cause undoubtedly rests with the availability of water.

Only a few fatal cases of waterborne diseases are now recorded in developed countries and outbreaks are exceptional. Infrequent episodes, such as the outbreaks of cryptosporidiosis in the United Kingdom and the United States, and a brief mini-epidemic of typhoid that occurred in 1963 at Zermatt, Switzerland, following a malfunction of the water supply and disposal system, are a reminder that vigilance is still required.

In developing countries, however, waterborne diseases are the largest single category of communicable diseases.
Cholera: Cholera affected many Latin American countries in 1991, the first such epidemic in the region this century. It had been assumed that improvements in water, sanitation, sewage treatment, and food safety had eliminated this disease just as it had in Europe and North America in the late nineteenth and early twentieth century, when large-scale cholera epidemics in major cities had helped spur major investment in improving water supplies and installing sewers.

The Latin American epidemic first appeared in Peru in January 1991, and by the end of the year more than 276,000 cases and 2,664 deaths from cholera had been reported. At the same time, 39,154 cases and 606 deaths had been reported in Ecuador. Cases were also reported in other Latin American countries and 24 cases were imported in the USA. The experience reminds us of the speed with which waterborne or water-washed infectious diseases can spread.

Less noted by the media at the time is the fact that cholera also remains a serious problem in many Asian and African countries. It is endemic in India and Indonesia and has been reported in Iraq. During the first half of 1991, 6,700 cases and 68 deaths had been reported for all of Asia. For the 19 African countries for which figures are available for 1991, a total of 134,953 cases were reported with 12,618 deaths. The actual numbers of cases of cholera occurring in the whole of Africa were considerably higher because other countries in the region were also known to have been hit by the epidemic.

Diarrhoea: Diarrhoea remains a very serious health problem. It contributes to infant mortality (1.5 million episodes of diarrhoea and some 4 million deaths per year) and is second only to tuberculosis in contributing to adult mortality (1 million deaths per year). Diarrhoea is usually caused by one of a number of waterborne pathogens including Giardia, Vibrio, and rotavirus, although it can also result from non-enteric infection.

Children under five years of age typically average 3.5 episodes of diarrhoea per year. Many children, however, have 10 or more episodes each year. Each episode lasts from 2-3 days to 2 weeks or more and may result in severe dehydration, the severity depending on the infectious organism, the intensity of the infection, and such host factors as age, nutritional status, and immunity. The weight loss that accompanies diarrhoea usually leads to acute malnutrition, and repeated episodes lead to chronic malnutrition. Malnutrition greatly increases the chance that a child will die.

Water-washed diseases - Scarcity and inaccessibility of water make washing and personal cleanliness difficult and infrequent. Where this is so, some diarrhoeal diseases and contagious skin and eye infections are prevalent. All waterborne diseases can also be water-washed diseases, transmitted by faecal-oral routes other than the ingestion of contaminated water (5). This category of diseases also includes infestation with lice or mites, which are vectors of various forms of typhus. Water-washed diseases diminish whenever an adequate supply of water is available and used.

Water-based diseases - Water provides the habitat for intermediate host organisms in which some parasites pass part of their life cycle. These parasites later cause helminthic diseases in people as their infective larval forms bore through wet skin (schistosomiasis), are eaten with raw or inadequately cooked water plants, crustaceans, or fish (liver and lung flukes), or infect a small water flea (Cyclops) which is then swallowed (guinea worm/dracunculiasis).

Among the many water-based diseases, schistosomiasis, guinea worm, roundworm, and hookworm stand out for the degree of debilitation they cause in human populations. Few people die of these diseases, but some are a cause of severe pain and suffering while others affect millions of people.
One of the most common water-based disease is schistosomiasis. Infection occurs through contact of the skin with water polluted by human excreta containing the eggs of a parasitic worm. These eggs hatch and the larvae penetrate various species of aquatic snail, where they reproduce. They are then released in a different larval form into fresh water, from where they can infect people coming into contact with it. Depending on the fluke species involved, chronic disturbances of the bladder or the gastrointestinal tract ensue. In the urinary form, cancer of the bladder is common in untreated cases, making it the most frequent cancer in Egypt. The population at risk worldwide is estimated at 600 million, the number infected at 200 million. The proportion of those infected who die from schistosomiasis is relatively low (estimates suggest up to 200 000 worldwide each year), but the disease results in a marked reduction of productivity in the population affected, mostly farmers, but increasingly urban dwellers as well. Poorly designed or poorly maintained irrigation and impoundment schemes have been responsible for the spread of the disease; the prevalence rose from 6% to 60% three years after the construction of the first Aswan dam (1906) and from 0% to 90% after the construction of the Volta dam (8, 9). The spread is due to the direct contamination of water with infected urine or stools and therefore to personal habits that are often rooted in tradition.

Guinea worm is caused by the ingestion of a small water flea (Cyclops) present in surface waters and containing the larvae of a worm (genus Dracunculus). When the barely visible flea is ingested, the larvae invade human tissues and develop into worms that can be 1 meter long, giving rise to a painful and debilitating chronic disease that among other things blisters the skin. From the blisters, new larvae are shed on contact with water, to infest other arthropods and, through them, more people. The number of people infected (Africa, south and west Asia) is of the order of 10 million and 100 million are at risk. Access to protected well-water prevents infection; improvements in sanitary conditions have eliminated the disease from most of Asia, the Eastern Mediterranean and large parts of Africa (7).

Water-related diseases - Water may provide a habitat for water-related insect vectors of disease.

Mosquitos breed in water and the adult mosquito may transmit malaria, filariasis, and virus infections such as dengue, yellow fever, and Japanese encephalitis. Different mosquitos may vary in their preference for different water bodies but are usually very specific in their requirements. Most malaria vectors require relatively clean water. Mosquitos, which spread filariasis, prefer to breed in flooded pit latrines and other highly polluted water. Blackflies (Simulium), which spread river blindness, breed in moving water, and deerflies (Chrysops) carrying eye worm (Loa loa) prefer muddy swamps. The tsetse flies that spread sleeping sickness (African trypanosomiasis), although breeding on land, bite near watercourses and can be effectively controlled by clearing the woodland that fringes the water for a distance of a few meters.

The spread of malaria (270 million infected, 110 million clinical cases per year, more than 1 million deaths per year, three-quarters in children aged under 5 years) has been facilitated by the extension of perennial irrigation agriculture. The presence of large bodies of standing water in the vicinity of human dwellings increases the likelihood of infection, especially in Asia and Latin America. In sub-Saharan Africa, the infection rate is already so high that it does not appear to be possible for the situation to worsen. Better management of water resources would improve matters, but the incidence of malaria can only be drastically reduced by effective and large-scale action including selective indoor spraying of insecticide and insect-repelling products, the use of personal protective measures (by children in particular), reliance on dependable prophylactic drugs (including, in the future, vaccines) and, where necessary, early treatment.
Some mosquito species breed in rain-filled discarded cans or containers near houses, including the main vectors of dengue (30 - 60 million infections per year with perhaps 100,000 clinical cases and 10,000 deaths) and yellow fever, a greatly under-reported disease (probably several hundred thousand cases a year with a case-fatality rate of over 50%).

Blackflies (Simulium) breeding in swift-running water transmit microfilariae that give rise to river blindness (onchocerciasis) in some parts of Latin America but especially in Africa (worldwide some 18 million infected, over 300,000 blind). Environmental measures are of limited effectiveness against river blindness except when settlements are moved away from the breeding grounds, but new therapeutic means used at an early stage are bringing the disease under control.

Water-dispersed infections - The four categories of water-related diseases described above are primarily problems of developing countries, although some can also occur in developed countries because of indigenous transmission or introduction by immigrants and travellers. A fifth category of diseases associated with water is emerging in developed countries - infections whose agents can proliferate in fresh water and enter the human body through the respiratory tract. Some freshwater amoebae that are not usually pathogenic can proliferate in warm water and if they enter the host in large numbers can invade the body along the olfactory tracts and cause fatal meningitis. Bacteria of the genus Legionella have demonstrated the capacity to proliferate in the water of complex air-conditioning systems, from which they may be dispersed as aerosols and infect substantial numbers of people through the respiratory tract. It is likely that other opportunistic pathogens will appear that find a suitable habitat in new technological devices using water. Other water-related infections such as that caused by waterborne Cryptosporidium may achieve increased clinical importance as the numbers of immunosuppressed people increase owing to acquired immunodeficiency syndrome (AIDS) or to chemotherapy facilitating organ or tissue transplants.

Let me re-emphasize that the health effects of the diseases associated with water are heavily concentrated in the developing world and, within the developing world, among the poorer urban and rural households of the poorer countries. Nearly half of the population in developing countries suffer from health problems associated with water.

4.0 WATER AND SANITATION

Safe and sufficient water supplies and adequate sanitation would reduce infant and child mortality by more than 50% and prevent a quarter of all diarrhoeal episodes (10). Safe water supplies would also eliminate guinea worm. Increasing the supply of water to households would greatly reduce the incidence of water-washed diseases, and improved sanitation could disrupt the cycle by which the agents of many waterborne and water-based diseases are returned to food, water, or soil. A review of studies on the health impact of water supplies found that, in most of the cases where water supply improvements were shown to have brought about a reduction in diarrhoeal diseases, the improvements included increased availability of water (10). Increased water availability would also help to control infectious skin diseases and infections carried by body lice (11,12).

Estimates of the numbers of people lacking access to safe and sufficient water supplies and adequate sanitation provide the best figures for the numbers of people at risk from water-related diseases. WHO estimates for 1988 suggest that 170 million urban and 770 million rural inhabitants lack access to safe and adequate water supplies and that over 1,700 million people lack adequate sanitation: 331 million urban and 1,388 million rural inhabitants (13). Most urban centres in Africa and Asia have no sewage system at all, including many cities with a million or more inhabitants (14). Most human excrement and household wastes end up, untreated, in rivers, streams, canals, gullies, and ditches. For
those cities with a sewage disposal system, the system rarely serves more than a small proportion of the population, typically in the richer residential, government, and commercial areas.

These figures for the number of people inadequately served with water and sanitation are likely to understate the problem, one reason being the lack of attention given in many projects to the quantity of water needed by an individual or household for health (12). For instance, the availability of a water tap within 100 meters of a house is often considered adequate by official agencies, but it is not necessarily adequate for the water needed for washing, cooking, and personal hygiene.

Moreover, official figures for the numbers of people adequately served often overstate the number actually served. For instance, they may assume that all those with water taps in their settlements are adequately served, but there are often so few communal water taps that people have to wait for a long time in queues and this tends to reduce water consumption to below what is needed for good health. Piped water systems in many tropical cities also function only intermittently for a few hours a day, which makes it especially difficult for households relying on communal taps. The water in piped systems is often of doubtful quality because of contamination of old and leaky distribution pipes by groundwater and sewage. Many urban dwellers in illegal settlements draw water from piped distribution systems through illegal connections and these are often a major source of leaks. Leaky distribution mains present an additional hazard when the water pressure is low and pollution from contaminated groundwater or wastewater from leaking drains and sewers may enter through damaged joints or pipe fissures when the pressure drops (12).

Many households and settlements judged by governments to be adequately served by public systems may resort to other water sources because of the problems mentioned above or may not be able to afford to purchase the water they need. Official figures for many of the poorer developing countries claim that over 80% of the urban population had access to safe water in the mid-1980s, including 100% coverage in Nigeria and Liberia and 99% coverage in Togo (13). Local specialists find it hard to reconcile these figures with the reality in the urban centres in which they work.

Improvements in the quality of the water supply and in its availability are usually possible at relatively low cost, especially if optimal use is made of local resources and knowledge. In many instances, cost recovery is possible. In cities where poorer households pay private water vendors at high cost, a proper piped water system can often replace the vendors and provide these households with a more economical and convenient supply at the same price as they previously paid to vendors (14, 15). A thriving informal market for water is evidence of a demand unsatisfied by the formal sector. It is also an indication of how much people would be willing to pay for an adequate conventional water supply if it were made available to them (12).

The cost of constructing water supplies varies widely, depending largely on the availability of water resources. For instance, for urban water systems in monsoon south-east Asia, a water supply with house connections can cost as little as US$60 per head, whereas in the arid Eastern Mediterranean area, it is likely to cost five times as much. A typical figure for a developing country might be US$120 per person served (12).

A cheaper alternative to water piped into each house is public standposts. These cost roughly half as much to build as house connections, say US$60 per head. The difference is not primarily due to savings in the cost of distribution pipes, as the distribution system normally accounts for only one-third of the total cost of a water supply; rather, it is due to the fact that those who use standposts consume much less water than...
households with private connections, so that there is less demand on the abstraction, treatment, pumping, and storage capacity of the system.

Households with taps in the yard of their homes use roughly half as much as those with house connections, so that the cost for them is nearer to the lower figure, say US$80 per person. To combine the construction costs with the annual operating costs of a system (typically about US$0.35 per cubic meter of water supplied), an equivalent annual amortization cost must be used.

Improved sanitation can be achieved at far less per capita cost than conventional sewerage systems and sewage treatment plants and is at the same time more effective and hygienic than the pit latrines or bucket latrines that remain the most widely used sanitation systems. The World Bank has identified a wide range of household and community systems that could greatly improve sanitation while taking due account of local physical conditions, social preferences, and economic resources (16). Several have a total annual cost per household of between one-tenth and one-twentieth of that of conventional sewerage systems. Most need far lower volumes of water for efficient operation. Some need no water at all.

5.0 WATER MANAGEMENT AND DISEASE PATTERNS

The increasing incidence of dengue fever and lymphatic filariasis in many urban areas is also worth noting. In urban areas there has been an increase in the breeding of clear-water mosquitos (Aedes). Aedes was formerly controlled in cities in the Americas by rigorous domestic inspection and removal of containers to control yellow fever. This disease is now rare and is effectively prevented by immunization. Aedes now causes massive epidemics of dengue fever. Where several serotypes of dengue are being intensely transmitted, as in many cities of south-east Asia, a severe and often lethal haemorrhagic shock syndrome occurs. It can be a major cause of child mortality. For instance, in an epidemic in Thailand in 1987, 174,285 cases and 1,007 deaths were reported. Over 89% of the cases and deaths were in infants and children under 14 years of age (17).

Ditches, sullage water, and flooded pit latrines in Africa and Asia are seeing more breeding of the culicine mosquitos (Culex). The increasing culicine populations of urban Asia and East Africa are not only a massive biting nuisance, they also transmit lymphatic filariasis, which is on the increase in tropical cities.

The causes of, and solutions to, the Aedes and Culex problems are primarily environmental. Insecticides in water cisterns may assist in combating Aedes. Expanded polystyrene beads can prevent Culex breeding in flooded pit latrines.

Wastewater is often the medium through which pollutants or pathogens can affect humans. Where water is scarce, the use of urban sewage and wastewater for irrigation is taking place on an increasing scale. Often, the sewage is partially treated and this makes it necessary to set firm limits on the crops grown and to institute appropriate techniques for water applications such as "drip" and "bubble" irrigation. Even then there are increased health risks for farmers and consumers, although health education can reduce them. In east and south-east Asia, raw excreta are often used to fertilize ponds used for aquaculture. The main health hazards arise when water is used for other domestic purposes or when fish infected with human parasites from faeces are eaten inadequately cooked or raw. Similar problems result from virus contamination of marine shellfish by sewage.
6.0 STRATEGIES FOR IMPROVEMENT

6.1 Overall Priority

The control of water pollution, whether it be by bacterial and parasitic waterborne pathogens or by chemical contamination must remain a priority. Providing cost-effective water and sanitation services for the urban poor is a fruitful way of both stimulating economic activity and combating the increasing squalor of today's peri-urban environment.

6.2 Management considerations

The fact that fresh water is limited both in quality and in quantity in most places indicates the need for comprehensive water management involving representatives of all water users. Among the objectives of such management are to ensure that the best use is made of available supplies (including protection from pollution) and to limit conflicts over access to fresh water.

Sound financial practices play an important and often neglected part in achieving better water management. Good water management should be based on recognition of the importance of safe and sufficient supplies for health and on the fact that fresh water is a scarce and finite resource and has a cost that, wherever possible, its users should bear.

Management techniques should include pricing structures that reflect real costs and encourage efficient use; users of large amounts of water (including large industrial and agricultural concerns) are often charged well below cost and are encouraged to overuse water, while a high proportion of the population lack access to piped water. A central aim of sound financial practice is to ensure that revenue from water sales is sufficient to maintain the water supply and management system. This involves demand management, cost containment to reduce wastage and ensure appropriate allocation of fresh water resources to competing uses, and cost recovery to manage demand and ensure the sustainability of the service.

6.3 Technological considerations

Major developments over the past 20 years in the application of new or revised techniques in water supply and sanitation have produced a range of options that permit cost-effective solutions appropriate to local conditions, cultures, and circumstances and can greatly improve health and environmental conditions.

Improvements in the quality and availability of the water supply are usually possible at relatively low cost, especially if the best use is made of local resources and knowledge. Two specific points are worth noting:

- Better maintenance and repair of existing water systems can often significantly increase the water supply. Many water supply systems lose up to 60% of the water from leaks in the pipes; reducing the leakage rate from 60% to 12% (the typical figure for systems in the UK or USA) would more than double the amount of water available for use (12). Just 20% of the leaks often account for 80% of the water losses (18).

- The design of water systems needs to be based on an analysis of local problems that assesses which combination of actions would make best use of local resources. Various approaches that may be considered unconventional by engineers trained in developed countries may prove to be the cheapest and most effective options; for instance, in some localities, government support to make water vendors more efficient and to improve water quality might be the most cost-effective option. In others, making...
use of local water sources for small independent networks for particular city areas may be more cost-effective than extending the water mains system. In areas with sufficient rainfall, grants to households to install guttering and rainwater tanks may be a cheap way of improving supplies.

6.4 Multisectoral considerations:

Experience with health care systems and basic services in the past ten years suggests that multisectoral intervention has much greater impact and cost-effectiveness, for instance when improved water supply and sanitation are combined with health care and hygiene education and, where needed, drainage.

Perhaps one of the most important advances over the past ten years is in knowledge of how to work with low-income groups and their community organizations. Among the key lessons learned (7, 12, 19) is the need for:

- more attention to strengthening the ability of communities or local government to run and maintain (and where possible build or improve) water or sanitation systems; for aid projects this means that they should be implemented within the existing administrative framework and not by the creation of autonomous or semi-autonomous project implementation units
- more emphasis on integrating water and sanitation improvements with other improvements, including environmental hygiene and primary health care
- involving local populations in decisions about the type of intervention, the design, implementation and evaluation of projects and the sharing of capital and recurrent costs
- survey and analysis of local environmental hygiene conditions, prevailing disease patterns, and relevant socioeconomic factors as inputs into the design and implementation of interventions
- more emphasis on the needs of those who have the primary responsibility for infant and child care, cooking, washing, and domestic hygiene (in most instances women), and for their full involvement in decisions about the nature and level of the projects planned, cost, types of repayment, and provision for maintenance
- specifying the role of nongovernmental organizations; NGOs, including many in developing countries, have often proved successful in promoting low-cost and effective approaches.

6.5 Summary

In summary, what seems to be lacking in most developing countries is a strategy and the institutional framework for health and sanitation. Governments and international agencies should make a renewed commitment to improving water supply and sanitation and should carefully review current policies to insure that they incorporate lessons learned over the past ten years.
7.0 References


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