Dirty Water:
Estimated Deaths from Water-Related Diseases 2000-2020

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Abstract

The failure to provide safe drinking water and adequate sanitation services to all people is perhaps the greatest development failure of the 20th century. The most egregious consequence of this failure is the high rate of mortality among young children from preventable water-related diseases. This paper examines different scenarios of activities in the international water arena and provides three estimates of the overall water-related mortality likely to occur over the next two decades.

If no action is taken to address unmet basic human needs for water, as many as 135 million people will die from these diseases by 2020. Even if the explicit Millennium Goals announced by the United Nations in 2000 are achieved[1] – unlikely given current international commitments – between 34 and 76 million people will perish from water-related diseases by 2020. This problem is one of the most serious public health crisis facing us, and deserves far more attention and resources than it has received so far.

Introduction

A wide range of water problems faces nations and individuals around the world. These problems include international and regional disputes over water, water scarcity and contamination, unsustainable use of groundwater, ecological degradation, and the threat of climate change. At the heart of the world's water problems, however, is the failure to provide even the most basic water services for billions of people and the devastating human health problems associated with that failure.

The United Nations, in collaboration with individual nations, regularly monitors access to water and sanitation. The most recently completed assessment, published in 2000 by the World Health Organization (WHO 2000), is the most comprehensive to date, providing information for 89 percent of the world's population. According to this assessment, 1.1 billion people around the world lacked access to "improved water supply" and more than 2.4 billion lacked access to "improved sanitation." Previous assessments were released in 1994, 1990, and during the International Safe Drinking Water Supply and Sanitation Decade of the 1980s.

While each of these assessments offers a picture of the populations without access to water services, different rates of response to surveys, inconsistent definitions of "access" and "adequate," and poor data availability make it difficult, and ill-advised, to draw conclusive trends over time. At the same time, despite problems with the data, it is evident that while progress has been made in providing water services to specific regions and areas, limited resources and rapidly growing populations have made it difficult to

[1] To halve, by 2015, the proportion of people who are unable to reach or to afford safe drinking water.

provide comprehensive and complete water coverage for all. The most serious consequence of this failure is widespread water-related disease and death.

Water-Related Diseases

Although water-related diseases have largely been eliminated in wealthier nations, they remain a major concern in much of the developing world. While data are incomplete, the World Health Organization estimated in the 2000 assessment that there are four billion cases of diarrhea each year in addition to millions of other cases of illness associated with the lack of access to clean water. Since many illnesses are undiagnosed and unreported, the true extent of these diseases is unknown.

Water-related diseases are typically placed in four classes: waterborne, water-washed, water-based, and water-related insect vectors. The first three are most clearly associated with lack of improved domestic water supply. Table 1 lists the diseases associated with each class.

Table 1: Water-Related Diseases

Waterborne diseases: caused by the ingestion of water contaminated by human or animal faeces or urine containing pathogenic bacteria or viruses; include cholera, typhoid, amoebic and bacillary dysentery and other diarrheal diseases.

Water-washed diseases: caused by poor personal hygiene and skin or eye contact with contaminated water; include scabies, trachoma and flea, lice and tick-borne diseases.

Water-based diseases: caused by parasites found in intermediate organisms living in contaminated water; include dracunculiasis, schistosomiasis, and other helminths.

Water-related diseases: caused by insect vectors, especially mosquitoes, that breed in water; include dengue, filariasis, malaria, onchocerciasis, trypanosomiasis and yellow fever.

Waterborne diseases include those where transmission occurs by drinking contaminated water, particularly contamination by pathogens transmitted from human excreta. These include most of the enteric and diarrheal diseases caused by bacteria and viruses. Waterborne diseases also include typhoid and over 30 species of parasites that infect the human intestines. Seven of these are distributed globally or cause serious illness: ameobiasis, giardiasis, *Taenia solium* taeniasis, ascariasis, hookworm, trichuriasis, and strongyloidiasis. Table 2 lists the current estimates of the prevalence of these diseases. Evidence also suggests that waterborne disease contributes to background rates of diseases not detected or reported explicitly as outbreaks.

Water-washed diseases occur when there is insufficient clean water for washing and personal hygiene, or when there is contact with contaminated water. These include trachoma, typhus, and diarrheal diseases that can be passed from person to person.

Water-based diseases come from hosts that live in water or require water for part of their life cycle. These diseases are usually passed to humans when they drink contaminated water or use it for washing. The most widespread examples in this category are schistosomiasis and dracunculiasis. Schistosomiasis currently infects 200 million people in 70 countries.

The final category – *water-related insect vectors* – includes those diseases spread by insects that breed or feed near contaminated water, such as malaria, onchocerciasis, and dengue fever. These diseases are not typically associated with lack of access to clean drinking water or sanitation services, and they are not included here in estimates of water-related deaths. It must be noted, however, that their spread is often facilitated by the construction of large-scale water systems that create conditions favorable to their hosts.

Table 2: Selected Water-Related Disease Morbidity and Mortality *

Diseases	Estimated Morbidity (episodes per year or people infected)	Estimated Mortality (deaths per year)	Relationship of Disease to Water and Sanitation Conditions
Diarrheal diseases	1,000,000,000	2,200,000 to 5,000,000	Strongly related to unsanitary excreta disposal, poor personal and domestic hygiene, unsafe drinking water
Intestinal helminths	1,500,000,000 (people infected)	100,000	Strongly related to unsanitary excreta disposal, poor personal and domestic hygiene
Schistosomiasis	200,000,000 (people infected)	200,000	Strongly related to unsanitary excreta disposal and absence of nearby sources of safe water
Dracunculiasis	150,000 (in 1996)	---	Strongly related to unsafe drinking water
Trachoma	150,000,000 (active cases)	---	Strongly related to lack of face washing, often due to absence of nearby sources of safe water
Poliomyelitis	114,000	---	Related to unsanitary excreta disposal, poor personal and domestic hygiene, unsafe drinking water
Trypanosomiasis	275,000	130,000	Related to the absence of nearby sources of safe water

Notes to Table 2:
This Table excludes mortality and morbidity associated with water-related insect vectors, such as malaria, onchocerciasis, and dengue fever.
Trachoma: This is the number of cases of the active disease. Approximately 5,900,000 cases of blindness or severe complications of Trachoma occur annually.

Source: World Health Organization (1996) and others (see Table 3 notes)

Mortality from Water-Related Diseases

Deaths from water-related diseases are inadequately monitored and reported. A wide range of estimates is available in the public literature, ranging from 2 million to 12 million deaths per year (see Table 3). Current best estimates appear to fall between 2 and 5 million deaths per year. Most of those dying from water-related disease are small children struck by virulent but preventable diarrheal diseases.

Table 3: Estimates of Water-Related Mortality

Source	Deaths per Year
World Health Organization 2000	2.2 million (diarrheal diseases only)
World Health Organization 1999	2.3 million
WaterDome 2002	more than 3 million
World Health Organization 1992	4 million
World Health Organization 1996	more than 5 million
Hunter et al. 2000	more than 5 million
UNDP 2002	more than 5 million
Johannesburg Summit 2002	more than 5 million
Hinrichsen et.al, 1997	12 million

Notes:

- WHO 1996. "Every year more than five million human beings die from illnesses linked to unsafe drinking water, unclean domestic environments and improper excreta disposal."
- Johannesburg Summit 2002. "More than 5 million people die each year from diseases caused by unsafe drinking water, lack of sanitation, and insufficient water for hygiene. In fact, over 2 million deaths occur each year from water-related diarrhea alone. At any given time, almost half of the people in developing countries suffer from water-related diseases."
- WHO World Health Report 1999. Statistical Annex. Totals of 2.3 million excluding several water-related diseases.
- WaterDome 2002. "More than 3 million die from diseases caused by unsafe water."
- Hunter et al. 2000. "Currently, about 20% of the world's population lacks access to safe drinking water, and more than 5 million people die annually from illnesses associated with unsafe drinking water or inadequate sanitation. If everyone had safe drinking water and adequate sanitation services, there would be 200 million fewer cases of diarrhea and 2.1 million fewer deaths caused by diarrheal illness each year."
- UNDP 2002. "We know it is the poor who are most affected, with 800 million people undernourished and 5 million dying each year because of polluted water, lack of sanitation, and waterborne diseases alone…"
- WHO. 1992. "Lack of sanitary conditions contributes to about two billion human infections of diarrhoea with about four million deaths per year, mostly among infants and young children."
- Hinrichsen, D., Robey, B., and Upadhyay, U.D. 1997. "Water-borne diseases are "dirty-water" diseases—those caused by water that has been contaminated by human, animal, or chemical wastes. Worldwide, the lack of sanitary waste disposal and of clean water for drinking, cooking, and washing is to blame for over 12 million deaths a year."

Other Health Consequences of Water-Related Diseases

As tragic and unnecessary as are water-related deaths, there are other significant health consequences that stem from the failure to provide adequate water services. These

include lost work days, missed educational opportunities, official and unofficial health care costs, and the draining of family resources. These are poorly understood and even more poorly measured and assessed. The focus of this research note is mortality, so we do not discuss these broader health consequences except to note their importance and to urge that better data be collected on the true economic and social costs of the failure to provide adequate water of appropriate quality.

Estimates of Future Deaths from Water-Related Diseases

The number of deaths anticipated from water-related diseases over the next two decades depends on many factors, including total global population, the relative rates of mortality from various diseases, the incidence of those diseases, interventions on the part of the health community, and future efforts to changes these factors.

According to the U.S. Bureau of the Census international data group and UN population estimates, global population between 2000 and 2020 will grow from just over 6 billion to as much as 7.5 billion, with most of the increase in developing countries of Africa and Asia (UN 2000a, US Census 2002). Projections of future water-related deaths will depend on these future population estimates as well as a wide range of other factors.

Excluding deaths from malaria and other diseases carried by water-related insect vectors, the best current international estimates of total water-related disease mortality range from 2.2 to 5 million annually, as shown in Table 3. We use this range in our calculations of future mortality to represent the uncertainty in projections. No "best estimate" is provided. The wide range of this estimate is, by itself, a strong indicator of the need for better monitoring and data collection on this public health problem.

Below are three model calculations of the total water-related deaths likely to occur between 2000 and 2020. The first assumes that water-related deaths continue to occur in direct proportion to global population. The second assumes that water-related deaths are more directly related to the population without access to adequate water services – a more realistic estimate – and that those numbers increase as global population increases. The third estimate assumes that the official United Nations Millennium targets for water services are reached in 2015 and efforts continue to 2020. These goals are defined below.

Estimate 1: No Action; Simple Proportional Projection

The simplest estimate of future deaths from water-related diseases comes from assuming that the proportion of deaths to total global population experienced today will be maintained in the future. As total population grows, total water-related deaths will grow annually. This can be seen in Equation 1, which applies a simple proportional assessment of water-related deaths to official median estimates of future population growth to 2020.

Equation 1: Deaths from Water-Related Diseases 2000 to 2020: Simple Proportional Assessment

$$\mathbf{TD_1 = \sum_{t=2000\ to\ 2020} (D/P)_{2000}(P_t)}$$

Where
TD_1 = Total water-related deaths, 2000 to 2020.
$\sum_{t=2000\ to\ 2020}$ = Sum over the period 2000 to 2020.
$(D/P)_{2000}$ = Water-related deaths in 2000/Global population in 2000.
P_t = Population in a given year.

The value for D is assumed to range from 2.2 to 5 million deaths per year, as described above. Using this range and the medium population path for 2020 leads to a projection that between **59 and 135 million people**, mostly children, will die between now and 2020 from preventable water-related diseases.

Estimate 2: No Action; Relative Proportional Projection

A more sophisticated approach calculates water-related deaths as a proportion of the population without access to clean water, rather than as a proportion of the total global population. This also is more realistic, since water-related deaths primarily occur within this subset of the population. Equation 2 shows this approach, which assumes no additional international efforts are made to improve access. The population without access to water-services in any given year is assumed to be proportional to that in 2000.

This approach leads to estimates that between **52 and 118 million people**, mostly children, will die between now and 2020 from preventable water-related diseases.

Equation 2: Deaths from Water-Related Diseases 2000 to 2020, Proportional to Population Without Access to Adequate Drinking Water (No Millennium Goal)

$$\mathbf{TD_2 = \sum_{t=2000\ to\ 2020} (D/PWA)_{2000}(PWA1_t)}$$

TD_2 = Total water-related deaths from 2000 to 2020 (no Millennium Goal).
$\sum_{t=2000\ to\ 2020}$ = Sum over the years 2000 to 2020.
$(D/PWA)_{2000}$ = Water-related deaths in 2000/Population without access to improved water supply in 2000.
$PWA1_t$ = Population without access to improved water supply in a given year (t), no Millennium Goal.
$PWA1_t = P_t\ (PWA_{2000}/P_{2000})$
P_{2000} = Global population in 2000.
P_t = Global population in year t.

Estimate 3: Meeting the UN Millennium Goals

It is reasonable to assume that additional actions will be taken in the next few years to accelerate the rate at which access to safe water is provided. An increasing number of nations, international water conferences, and aid organizations have announced efforts to improve global access to water. For example, the recent ministerial statement from the World Water Forum in 2000 in The Hague (Hague 2000) called for efforts to guarantee

> "that every person has access to enough safe water at an affordable cost to lead a healthy and productive life and that the vulnerable are protected from the risks of water-related hazards…."

In September of the same year, the United Nations General Assembly adopted The Millennium Goals (UN 2000b), which among other explicit targets called for the world community:

> "To halve, by the year 2015…the proportion of people who are unable to reach or to afford safe drinking water.

Efforts to meet this Millennium Goal will lead to a decrease in the total population without access to safe drinking water, but it will not come close to eliminating the problem. Meeting the goal will reduce total population without access by approximately 30 million people per year from an estimated 1.1 billion in 2000 to 650 million in 2015 and 500 million in 2020 if the effort continues past 2015. If today's water-related death rate is applied to this decreasing population, the total number of deaths between 2000 and 2020 will drop substantially. Equation 3 computes the number of deaths from water-related diseases estimated to occur if the death rate remains proportional to the population without access to adequate drinking water (as in Equation 2), but that population size decreases in line with the Millennium Goal requirements to 2015 and beyond.

Equation 3: Deaths from Water-Related Diseases 2000-2020, Proportional to Population Without Access to Adequate Drinking Water (Meeting Millennium Goal)

$$TD_{MG} = \sum_{t=2000 \text{ to } 2020} (D/PWA)_{2000}(PWA2_t)$$

TD_{MG} = Total water-related deaths from 2000 to 2020 (meeting Millennium Goal).
$\sum_{t=2000 \text{ to } 2020}$ = Sum over the years 2000 to 2020
$(D/PWA)_{2000}$ = Water-related deaths in 2000/Population without access to improved water supply in 2000
$PWA2_t$ = Population without access to improved water supply in year "t", meeting Millennium Goal
$PWA2_t = (PWA_{t-1} - \Delta P_{tMG})$
PWA_{t-1} = Population without access to improved water supply in year "t-1" ($PWA_{t=2000}$ = 1.1 billion).
ΔP_{tMG} = Change in annual population without access to improved water supply to meet Millennium Goal. This value is computed using a linear rate of improvement between now and 2015 – approximately 30 million people per year.

Equation 3 leads to estimates that between **34 and 76 million people**, mostly children, will die between now and 2020 from preventable water-related diseases. Figure 1 shows the upper and lower limits for total water-related deaths as estimated by Equations 2 and 3.

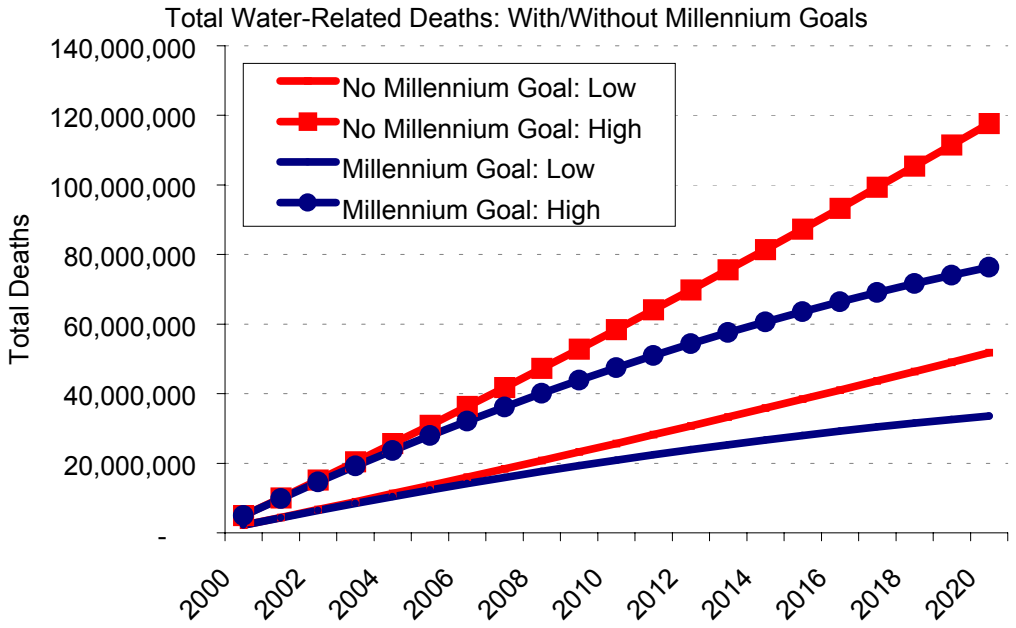

Figure 1: Total water-related deaths between 2000 and 2020. The red lines (top and third from top) show the range of deaths likely to occur without the UN Millennium Goals. The blue lines (second from top and bottom) show the range of deaths even if the Millennium Goals are achieved. This range is 34 to 76 million deaths total by 2020.

Other Factors

These estimates can and will be refined with additional data. For example, improvements in water supply may not be linear but may start out slowly and accelerate over time. This would increase the number of deaths annual in the short run (compared to Estimate 3) and decrease them toward the end of the period. In addition, better medical care could reduce overall mortality as a fraction of morbidity. These interventions by the medical community are indeed improving, but not at easily modeled rates.

Solutions: What Do We Do?

While this research paper does not allow for a detailed discussion of approaches for solving the devastating problem of water-related illness and death, we offer some thoughts for consideration. Millions of deaths will continue to occur every year from water-related diseases unless far more aggressive actions are taken to meet basic human needs for safe water and sanitation. The UN Millennium Goals, while important quantitative targets, are inadequate alone: they must be coupled with specific and aggressive commitments on the part of countries and international organizations.

The approaches chosen by international aid organizations have so far not solved the problem of access to safe water. Far too much money has been spent on centralized, large-scale water systems that cannot be built or maintained with local expertise or resources, while traditional and community-scale systems have been inadequately funded and supported. It is time to change direction, toward a "soft path" that relies on smaller-scale systems designed, built, and operated by local groups.[2] Outside assistance in the form of information, funding, and expertise is certainly still required, but this assistance must be directed in new and different ways.

Finally, a new and different commitment is needed on the part of the international water community. Priority should be given to meeting unmet human needs for water rather than large-scale irrigation or hydroelectric facilities. A recommitment to the elimination of certain water-related diseases, such as dracunculiasis, is needed. Research into inexpensive, small-scale technologies is likely to lead to new and exciting breakthroughs that can be implemented quickly and cheaply. And education on hygiene, sanitation, and water quality should be expanded worldwide. Only by a combination of these methods can real progress be made.

Conclusions

The failure to meet basic human needs for water is widely acknowledged to be a major development failure of the 20th century. Yet efforts to provide universal coverage for water and sanitation continue to be largely rhetorical and piecemeal. The price for this failure will be paid by the poorest populations of the world in sickness, lost educational and employment opportunities, and for a staggeringly large number of people, early death. Even if the official United Nations Millennium Goals set for water are met – which is unlikely given the current level of commitments by national governments and international aid agencies – ***as many as 76 million people will die by 2020 of preventable water-related diseases***. This is morally unacceptable in a world that values equity and decency, but at the present time, it appears unavoidable unless we rethink our approach to providing water and sanitation services and redouble international efforts to aid those lacking this most basic of human needs.

[2] A more detailed description of the "soft path" for water can be found in Wolff and Gleick (2002).

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