Dying for Clean Water

Author: Dr. Kristen Kerksiek
May 14, 2009

„Children of a culture born in a water-rich environment, we have never really learned how important water is to us. We understand it, but we do not respect it."
WILLIAM ASHWORTH, Nor Any Drop to Drink, 1982.

Water is so important for life but sometimes nothing more than a deadly cocktail.

Most of us don't think much about water. We don't need to. We have an ample supply of it flowing from our faucets. And if you don't like the taste of it from the tap, there's a wide selection of bottled water available at the local store. It's plentiful, inexpensive and of course safe – just as it should be. It's easy to forget that a large chunk of the world's population (currently ~6.77 billion) isn't so lucky. An estimated 1.1 billion people don't have access to safe drinking water, and more than twice as many live with inadequate sanitation. While the consequence is predictable, the numbers are staggering: lack of clean drinking water causes more than 2 million deaths each year, 90% of which are children under the age of five. The microbial culprits are well-known, and the infections they cause are for the most part both preventable and treatable. Yet they strike again and again. Case in point: as of April 16, the cholera outbreak that hit Zimbabwe last August had officially infected 96,591 and killed 4201, making it the largest African outbreak in 15 years.

Cholera

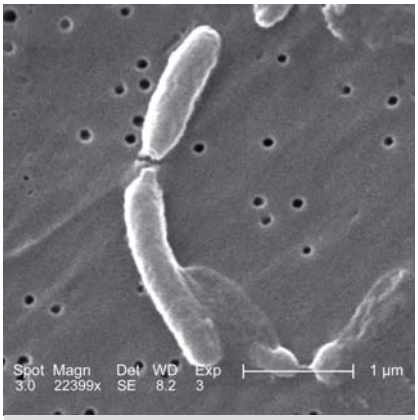
- caused by *Vibrio cholerae*, a motile Gram-negative curved bacillus
- identification of *V. cholerae* by Filippo Pacini in 1854 largely unrecognized; independently isolated and publicized by Robert Koch in 1883
- spread mainly by fecal-oral route or ingestion of contaminated food or water; also some aquatic sources, infection associated with algal blooms
- ~ 75% of infected people don't develop symptoms but can spread bacteria
- very short incubation period: 2 hours to 5 days
- predominant symptom is acute watery diarrhoea caused by cholera toxin
- if untreated, death can occur 12–18 hours after the first symptoms appear
- treatment: oral rehydration therapy (ORT; salt and sugar solution): if treated properly, death rate <1%; antibiotics reduce disease severity and shorten course

„Water and air, the two essential fluids on which all life depends, have become global garbage cans."
JACQUES COUSTEAU

Although there are scattered reports of a cholera-like illness dating from antiquity, cholera's history as a scourge of humanity is relatively short. In the early 19th century, *V. cholerae* left its endemic home in the region of the Ganges and Brahmaputra Rivers in India and Bangladesh, traveling the world via trade routes and causing seven global epidemics that killed millions of people; the last pandemic began in 1961 and is still ongoing.
Cholera was one of the first diseases whose mode of transmission was understood. In the 1850s, the British physician John Snow showed that cholera is spread by drinking water; his epidemiological work linked cholera outbreaks to contaminated wells and demonstrated that water taken from the Thames upstream of London (before sewage entry) posed a much lower cholera risk than that from the contaminated Central Thames. However, his message was not warmly welcomed in a community that still favored either the miasma ("bad air") theory of infection or divine intervention.

In 1854, an epidemic centering around the Broad Street Pump in London killed more than 500 people in a matter of days.

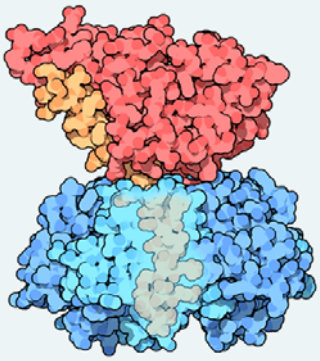
It took decades before effective sanitation was implemented, but Europe, North America and other developed countries have suffered comparatively little from cholera and other water-borne illnesses over the last century due to advances in public health. The same can unfortunately not be said for much of the developing world. Over the last decades, South America, South Asia and Africa have been hard hit by cholera. In the 1990s – after a century of being cholera-free – *V. cholerae* returned to Latin America, spreading quickly throughout the continent and infecting more than a million people. However, investments in sanitation, drinking water and health care succeeded in nearly eliminating the disease (as well as reducing typhoid fever, hepatitis A and child mortality) by the end of the decade. In its native India and Bangladesh, cholera outbreaks often follow monsoonal flooding, and many other Asian countries including Iran, Iraq, Indonesia, Vietnam, the Philippines and China have also suffered outbreaks in recent years. However, it is in Africa – where the epidemic has had a foothold for more than 30 years – that cholera takes its largest toll.



Typical comma-shaped *Vibrio cholerae* bacteria.
© CDC/ Janice Carr

„Filthy water cannot be washed“
AFRICAN PROVERB

Cholera is one of only three diseases for which cases must – under International Health Regulations – be reported to the World Health Organization. Nevertheless, the WHO estimates that only 5–10% of cholera infections are officially reported. In 2005 there were nearly 132,000 official cases of cholera worldwide; more than 125,000 (95%) were in sub-Saharan Africa, with Senegal, Guinea-Bissau and the Democratic Republic of the Congo suffering the largest outbreaks. The case fatality rate in Africa was 1.78%, almost triple that in Asia (0.62%); no deaths were reported on other continents. Why?



The delivery region (blue) of cholera toxin binds membrane carbohydrates to get into cells. The toxic part (red) is activated inside the cell.
© David S. Goodsell of The Scripps Research Institute

There are a variety of factors that make African countries so susceptible to cholera outbreaks. The basic problem - a lack of clean water sources together with inadequate sanitation – is multifactorial: adverse climatic conditions, weak governments, corruption and mismanagement of resources are some of the factors involved. The problems of water scarcity and contamination are exacerbated by the large number of people displaced by armed conflict or natural disaster, an estimated 2,270,000 in 2007 according to the United Nations Refugee Agency (excluding North Africa). Refugee camps are hotspots for disease outbreaks, as weakened (malnourished, ill) persons are crowded under insanitary conditions.
The developing countries in Africa have also experienced mass migration of peasants to large cities, where overcrowded “shantytowns” provide another disease hotspot. In cities such as Bissau in the West African country Guinea-Bissau, the water infrastructure – dating from colonial times – is outdated, badly maintained and strained by the ever-increasing demand. And then there’s Zimbabwe. Once an African success story with impressive public health structures, the infrastructure has decayed under the current “leadership”, providing the setting for the ongoing cholera epidemic: the breakdown of water and sanitation services enabled *V. cholerae* to reach so many, and the collapse of the medical system resulted in a case fatality rate of more than 5% during parts of the epidemic. The Zimbabwe cholera epidemic is an extreme, but it reflects the urgency of the water problem in Africa.

Irdimi refugee camp, Tschad: A fugitive girl collects water from a well. © UNO-Flüchtlingshilfe

Cholera in bad company: other water- and sanitation-related infectious diseases

Disease	Causative agent(s)	Facts
Diarrhea	Various bacteria, viruses, parasites	Kills 1.8 million annually, 90% (1.6 million) children under the age of 5
Hepatitis	Hepatitis viruses A and E	Hepatitis A and E can be transmitted via water and food (fecal-oral route)
Intestinal worms	Roundworm (Ascariasis), Hookworm, Whipworm	~10% of people in developing world infected; causes malnutrition, anemia, retarded growth
Schistosomiasis	flukes (flatworms) of the genus Schistosoma	Second most important parasitic infection after malaria (health/economic impact); 200 million infected worldwide
Trachoma	bacterium *Chlamydia trachomatis*	Most common infectious blindness: 150 million infected, 6 million blind worldwide (WHO)
Typhoid Fever	bacterium *Salmonella enterica* serovar Typhi	Estimated to infect 21 million and kill 200,000 each year (WHO, CDC)

For more information see the WHO's Water and Sanitation-Related Diseases Fact Sheets: http://www.who.int/water_sanitation_health/diseases/diseasefact/en/index.html

The worldwide population growth of nearly 75 million each year isn't going to make it easier to provide sufficient safe water for all. The water problem is widely expected to dramatically worsen over the next decades, with the UN itself projecting that almost half the world's population will experience water shortages by the year 2030. Although the cholera epidemic continues, our attention has wandered away from Zimbabwe. We cannot afford to do the same with - to ignore or forget – the trouble with water.

"The trouble with water—and there is trouble with water—is that they're not making any more of it. They're not making any less, mind, but no more either. There is the same amount of water in the planet now as there was in prehistoric times. People, however, they're making more of—many more, far more than is ecologically sensible—and all those people are utterly dependent on water for their lives (humans consist mostly of water), for their livelihoods, their food, and increasingly, their industry. Humans can live for a month without food but will die in less than a week without water. Humans consume water, discard it, poison it, waste it, and restlessly change the hydrological cycles, indifferent to the consequences: too many people, too little water, water in the wrong places and in the wrong amounts."

Marq de Villiers

References and further reading:

More information about how cholera wreaks havoc on the intestine can be found here: www.textbookofbacteriology.net/cholera.html

March 22 was World Water Day. Find out more: www.worldwaterday.net

Extensive information about cholera, including epidemiological records, is provided by the World Health Organization (WHO): www.who.int/topics/cholera/en/

A Lion in Our Village — The Unconscionable Tragedy of Cholera in Africa
Eric D. Mintz, M.D., and Richard L. Guerrant, M.D.
NEJM 360: 1060-1063 March 12, 2009: content.nejm.org/cgi/content/full/360/11/1060

The 3rd United Nations World Water Development Report: Water in a Changing World (WWDR-3) http://www.unesco.org/water/wwap/wwdr/wwdr3/

For more information about John Snow, widely held to be the father of modern epidemiology, and the famous Broad Street Pump cholera outbreak (London, 1854) click here: www.ph.ucla.edu/epi/snow.html

The IPS (InterPressService) News Agency publishes a variety of water- and environment-related articles online: www.ipsnews.net/new_focus/water/index.asp

Recent scientific articles:
Researchers are trying find ways to predict cholera outbreaks using satellite monitoring and evaluation of climatic factors:

Constantin de Magny G. et al. Environmental signatures associated with cholera epidemics. Proc. Natl. Acad. Sci. USA 2008. 105:17676-17681. doi:10.1073/pnas.0809654105

Luque Fernández M.A. et al. Influence of temperature and rainfall on the evolution of cholera epidemics in Lusaka, Zambia, 2003-2006: analysis of a time series. Trans. R. Soc. Trop. Med. Hyg. 2009. 103:137-143. doi:10.1016/j.trstmh.2008.07.017

In his dispute with Robert Koch over the causative agent of cholera, Max von Pettenkofer – doubter of a pure microbial cause - drank a culture of *V. cholerae*. When he didn't fall ill, Pettenkofer thought his reservations confirmed. Recent research indicates that during human colonization *V. cholerae* can enter a hyperinfectious state that may enable its epidemic spread:

Merrell D.S. et al. Host-induced epidemic spread of the cholera bacterium. Nature 2002. 417: 642-645. doi:10.1038/nature00778