

In 2005-2006, the Centers for Disease Control and Prevention (CDC) reported 28 outbreaks related to drinking water and 78 outbreaks associated with recreational water, resulting in more than 5,000 illnesses and 7 deaths.¹

For more information, please contact **Kim Knowlton** at (212) 727-4579.



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Rising Tide of Illness: How Global Warming Could Increase the Threat of Waterborne Diseases

Although there is little public discussion of the problem, disease outbreaks caused by contaminated water occur regularly. Researchers estimate that, including unreported cases, between 4 and 33 million waterborne gastrointestinal illnesses occur each year in the United States.² Global warming is projected to increase the risk of more frequent and more widespread outbreaks of waterborne illnesses, due to higher temperatures and more severe weather events.

To help prevent increased occurrence of water-related illnesses, the CDC should improve surveillance of waterborne disease outbreaks, the Environmental Protection Agency (EPA) should improve water quality regulations, and Congress should act to limit emissions of global warming pollutants. We need to act now to protect public health today while preparing for the impacts of climate change.

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Case Study: *Naegleria*: The “Brain Eating Amoeba”

“It seemed like nothing more than a headache,” said the father of a young boy who contracted a fatal infection caused by the hot water-loving *Naegleria fowleri*.¹⁵ The 14 year-old boy’s symptoms had appeared only days after swimming in a lake on a hot Arizona summer day in 2007. The lake’s waters were the source of the deadly pathogen, which enters the brain through the nose. Symptoms of *Naegleria* infection include stiff neck, fever, headaches, then hallucinations and erratic behavior. Once inside the body, the amoeba travels into the brain and destroys brain cells, causing Primary Amebic Meningoencephalitis (PAM). The disease is nearly always fatal. In 2007 (which had the warmest global land surface temperature on record), six young men and boys in the United States died after swimming in natural bodies of water and becoming infected with *Naegleria*.¹⁷ Although the infection is extremely rare and confined to the southern tier of United States, officials at the CDC believe that warming temperatures will increase the number and geographic range of this “heat-loving amoeba,” potentially leading to more cases.¹⁸

Waterborne Diseases Already Pose Serious Health Risks

There are dozens of waterborne viruses, bacteria and parasites that cause illnesses with symptoms including nausea, vomiting, diarrhea, headache, fever, skin rashes, eye, ear, respiratory, and wound infection, and even life-threatening neurological conditions.³ People typically get waterborne illnesses through ingestion, inhalation, or contact with contaminated water. Most contamination of drinking and recreational water occurs when human or animal feces from farms, septic or wastewater systems, or urban areas flows into ground or surface water. Although many wastewater and water treatment systems are effective at removing pathogens, heavy rainfall and large amounts of runoff can compromise the efficacy of those systems.⁴ Even single-outbreak events can reach a large scale; a cryptosporidiosis outbreak in Milwaukee in 1993 involving contaminated drinking water resulted in more than 400,000 illnesses and 69 deaths.

This problem is heightened in areas that use combined sewer systems, where rainwater and sewage are carried in the same pipes.⁵ During heavy rain events these systems can overflow, sending raw sewage into rivers, lakes and coastal waters. In fact, studies indicate that more than half of the waterborne disease outbreaks in the United States over the last 50 years have been associated with heavy rain events.⁶ When contaminated water is used for irrigation, waterborne pathogens can also contaminate food, creating another route of exposure.

Some Populations Are at Even Greater Risk

In healthy adults most waterborne diseases can be temporarily debilitating, but generally are not life-threatening. However, for some people these illnesses can be severe or fatal. At-risk groups include people with compromised immune systems, infants, the elderly, and pregnant women. In addition, some waterborne pathogens can lead to serious conditions in even the healthiest people. Such health threats include liver failure (Hepatitis A), kidney failure (*E. coli*), severe pneumonia (Legionnaires’ disease) and neurological conditions (*Naegleria*—for more on this pathogen, see the case study text box).

Global Warming Will Fuel a Rise in Waterborne Illness

The risk of waterborne illness is likely to increase with climate change. Climate models project that the average temperature could climb by more than 4°C (7.2°F) by the end of the 21st century, and many models also suggest that extreme rainfall events will increase in frequency.^{7,8} These changes can lead to heightened waterborne disease risks because warmer temperatures can increase the risks of waterborne pathogen exposure. A 2004 outbreak of *Vibrio parahaemolyticus*, a bacteria typically associated with warm ocean temperatures, sickened 62 passengers on a cruise ship when it showed up for the first time in oysters harvested from Alaskan waters, indicating rising water temperatures.⁹ Other pathogens such as *Legionella* reproduce more quickly in warmer environments.

Predictions also call for more periods of drought, which will affect subsoil structure so that new water movement patterns may be created that will open groundwater sources to contamination they would not experience in wetter periods. These changes may lead to significant impacts on drinking water and recreational water quality, putting people at greater risk of contracting a waterborne illness. Runoff from extreme rainfall events is one of the chief drivers of water contamination.

An increase in major rainfall events is a particular threat in areas with combined sewer systems such as the Great Lakes region, which provide drinking water for more than 40 million people.¹⁰ With increasingly frequent heavy rain events predicted by most climate change models, the frequency of sewage releases into the Great Lakes is projected to rise by 50 to 120 percent by the end of the century.¹¹ Monthly increases in temperature and precipitation have already been linked to increases in cryptosporidiosis.¹² Waterborne disease outbreaks related to recreational waters occur most frequently in the summer because people are more likely to go swimming and be in direct contact with contaminated water.¹³ With climate change models projecting an increase in mean temperature and extreme heat events in future summers, the use of recreational waters could grow—exposing more people to waterborne pathogens.¹⁴

Recommendations for Protecting Water Resources and Safeguarding Health

Keeping waterborne illness in check during the coming decades will require a comprehensive approach to protecting water supplies, improving sanitation, and curbing global warming so as to minimize the changes in climate that fuel waterborne illness.

Protect Drinking Water

1. Increase funding for maintaining and updating the aging drinking water infrastructure (to prevent contamination of storage tanks with improper or broken covers, cracks in the pipes that can let sewage into the drinking water, etc.)
2. Increase funding for inspecting distribution systems (to identify problems like the broken covers, etc.)

Strengthen Disease Tracking and Monitoring

1. Improve funding for state and local public health agencies responsible for waterborne disease outbreak detection, investigation, and reporting.
2. Improve the waterborne disease and outbreak surveillance system by:
 - Making sure practitioners know that waterborne disease outbreaks are nationally notifiable in all states and went electronic in May 2009;
 - Expanding reporting partners (e.g. Department of Defense, Indian Health Service, National Park Service, etc.);
 - Improving training and education of waterborne disease investigators;
 - Collecting more extensive risk factor and causal data on corrosion/leaching and low-pressure events, etc.;
 - Creating linkages between national water databases for analysis purposes and improving their communication; and
 - Educating the public to increase awareness of waterborne disease outbreaks.

Improve Sanitation

1. Upgrade capacity of municipal wastewater treatment systems, and keep stormwater out of the system by using green infrastructure, so that they can handle combined sewer overflow during extreme storm events.
2. Institute better controls on septic systems in rapidly-growing suburban and rural areas.



Heavy rains can lead to storm sewer overflow.

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Important Waterborne Illnesses¹⁶

Pathogen	Water-related route of exposure	Symptoms
Parasites		
<i>Cryptosporidium</i>	Ingesting contaminated drinking or recreational water	Watery diarrhea, stomach cramps, vomiting, fever, nausea; can cause chronic life-threatening diarrhea in people who have AIDS or other immunological problems.
<i>Giardia intestinalis</i>	Ingesting contaminated drinking or recreational water	Diarrhea, stomach cramps, nausea
<i>Naegleria fowleri</i>	Getting contaminated water up your nose while swimming in freshwater. Occasionally due to getting contaminated drinking water up the nose.	Headache, fever, nausea, vomiting, stiff neck, neurological deficits, coma, and death. <i>Naegleria</i> infections are almost always fatal.
Bacteria		
<i>Campylobacter</i>	Ingesting contaminated drinking or recreational water	Diarrhea (sometimes bloody), stomach cramps, fever, nausea, vomiting
<i>E. coli</i>	Ingesting contaminated drinking or recreational water	Diarrhea (sometimes bloody) and abdominal cramps. Some types of <i>E. coli</i> can lead to kidney failure.
<i>Legionella</i>	Inhalation of contaminated mist from shower heads, cooling towers, hot tubs, etc.	Fever, chills, cough, muscle ache, headache, severe pneumonia
<i>Pseudomonas aeruginosa</i>	Skin or outer ear canal contact with contaminated water in swimming pools, hot tubs, etc.	Itchy red bumps, blistering, rash, or outer ear infections; pain caused by infection ("swimmer's ear")
<i>Salmonella</i>	Ingesting contaminated drinking or recreational water	Diarrhea, fever, and abdominal cramps
<i>Shigella</i>	Ingesting contaminated drinking or recreational water (typically recreational)	Diarrhea (sometimes bloody), nausea, vomiting, stomach cramps, fever
<i>Vibrios</i> (<i>V.parahaemolyticus</i> , <i>V.vulnificans</i> , <i>V.cholera</i>)	Ingesting contaminated water, getting contaminated water into cuts	Vomiting, diarrhea, abdominal pain, wound infections
Viruses		
Norovirus	Ingesting contaminated drinking or recreational water	Nausea, vomiting, diarrhea, stomach cramping, fever, chills, headache, muscle aches (highly contagious)
Hepatitis A	Ingesting contaminated drinking or recreational water	Jaundice, liver damage, fatigue, nausea, vomiting, fever
Pharyngoconjunctival fever (PCF)	Ingesting contaminated recreational water	Sore throat, cough, fever, headache, muscle pain, malaise, and "pink eye"
Aseptic meningitis	Ingesting contaminated recreational water	Headache, neck stiffness, nausea, sensitivity to light, cough, sore throat, diarrhea

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Clean Up and Protect Recreational Waters

1. Tighten and enforce EPA and state controls on all sources of beachwater pollution. Controls on sewage overflows, urban stormwater, and other sources of polluted runoff are particularly critical. The best way to prevent swimmers from getting sick is to clean up the water.

2. Make preventing beachwater pollution a priority, adopt monitoring and closure programs that adequately protect the public, and conduct sanitary surveys to identify and then remedy the sources of beachwater pollution.

3. Pass the federal Clean Coastal Environment and Public Health Act of 2009, which would reauthorize the BEACH Act of 2000; double the proposed funding and allow that funding to be used for identifying and correcting sources of beachwater contamination; require the EPA to approve rapid test methods for monitoring beachwater pollution; and improve coordination between the public health officials who monitor the beachwater and the environmental agencies who regulate the sources of beachwater pollution.

Curb Global Warming

1. Reduce global greenhouse gas emissions at the international, federal, state, and local levels. Cutting the amount of global warming pollution emitted from sources such as power plants, industry, and automobiles will slow the climate changes that can lead to increased waterborne illnesses. Passage of strong and comprehensive legislation that sets limits on global warming pollution and directs investments toward clean energy technologies will provide the double benefit of helping to protect water supplies and global health.

Other forms of water contamination, such as chemicals or harmful algal blooms, may also increase as a result of global warming and can cause waterborne diseases. Investing now in enhanced environmental monitoring and improved health reporting can help us understand the relative contribution of factors (both climate and non-climate related) influencing waterborne diseases and strengthen our climate-health preparedness, both now and for the future.

- ¹ Yoder J, et al. (2008). Surveillance for Waterborne Disease and Outbreaks Associated with Drinking Water and Water Not Intended for Drinking- United States, 2005-2006 *MMWR Surveillance Summaries* 57 (SS09):39-62; Yoder, J. et al. Surveillance for Waterborne Disease and Outbreaks Associated with Recreational Water Use and Other Aquatic Facility-Associated Health Events—United States, 2005—2006. *MMWR Surveillance Summaries* 2008; 57(SS09):1-29.
- ² Colford JM, et al. (2006). A review of household drinking water intervention trials and an approach to the estimation of endemic waterborne gastroenteritis in the United States. *Journal of Water and Health* 4 (Suppl 2):71-88; Messner M, et al. (2006). An approach for developing a national estimate of waterborne disease due to drinking water and a national estimate model application. *Journal of Water and Health* 4 (Suppl 2):201-240. Available at: http://www.cdc.gov/healthywater/statistics/surveillance/national_estimate_waterborne_disease.html
- ³ Rose JB, et al. (2001). Climate variability and change in the United States: Potential impacts on water- and foodborne diseases caused by microbiological agents. *Environ. Health Perspect* 109:211–221.
- ⁴ Curriero FC, et al. (2001). The association between extreme precipitation and waterborne disease outbreaks in the United States, 1948–1994. *Am J Public Health* 91:1194–99.
- ⁵ EPA. Report to Congress: Impacts and control of CSOs and SSOs. Aug 2004.
- ⁶ *Ibid.*; Dorfman M, et al. (2009). *Testing the Waters: A Guide to Water Quality at Vacation Beaches* (19th ed.). Natural Resources Defense Council (July 2009). Available at: <http://www.nrdc.org/water/oceans/ttw/twmap.asp>.
- ⁷ Field, C.B., L.D. Mortsch., M. Brklacich, D.L. Forbes, P. Kovacs, J.A. Patz, S.W. Running and M.J. Scott, 2007: North America. *Climate Change 2007: Impacts, Adaptation and Vulnerability. Contribution of Working Group II to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change*, M.L. Parry, O.F. Canziani, J.P. Palutikof, P.J. van der Linden and C.E. Hanson, Eds., Cambridge University Press, Cambridge, UK, 617-652.
- ⁸ Christensen JH, et al. (2007). *Regional climate projections. Climate Change 2007: The Physical Science Basis. Contribution of Working Group I to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change*. S. Solomon, D. Qin, M. Manning, Z. Chen, M. Marquis, K.B. Averyt, M. Tignor and L. Miller, Eds., Cambridge University Press, Cambridge and New York, 847-940.
- ⁹ McLaughlin JB et al. (2005). Outbreak of *Vibrio parahaemolyticus* gastroenteritis associated with Alaskan oysters. *NEJM* 353:1463-1470.
- ¹⁰ EPA (2004)
- ¹¹ Patz JA, et al. (2008). Climate change and waterborne disease risk in the Great Lakes region of the U.S. *Am J Prev Med* 35(5): 451-458.
- ¹² Jagai, J.S. et al. Seasonality of cryptosporidiosis: a meta-analysis approach. *Env Res* 109 (2009):465-478.
- ¹³ Yoder et al. (2008)
- ¹⁴ Ebi KL, et al. (2008). Effects of Global Change on Human Health. In: *Analyses of the effects of global change on human health and welfare and human systems*. A Report by the U.S. Climate Change Science Program and the Subcommittee on Global Change Research. [Gamble, J.L. (Ed.), K.L. Ebi., et al. (authors)]. US EPA, Washington, DC, pp.2-1 to 2-78 (Table 2-2, p.2-62).
- ¹⁵ MSNBC (Sept 29, 2007). "6 die from brain-eating amoeba after swimming," <http://www.msnbc.msn.com/id/21034344/>.
- ¹⁶ Centers for Disease Control and Prevention (CDC) (2009). Water-related diseases, contaminants and injuries. <http://www.cdc.gov/healthywater/disease/az.html>; and Healthy Swimming website at: <http://www.cdc.gov/healthyswimming/mmwr.htm>
- ¹⁷ Matthews S, et al. (2008). Primary Amebic Meningoencephalitis – Arizona, Florida, and Texas, 2007. *MMWR Weekly* (May 30, 2008) 57(21):573-577.
- ¹⁸ Dziuban EJ, et al. "Surveillance for waterborne disease and outbreaks associated with recreational water—United States, 2003-2004." *MMWR Surveillance Summary*. Dec 2006. 55(12): 1-30.