**Water and Foodborne Diseases from Extreme Weather Events in the U.S.**

**Abstract**

Weather and climate have affected human health for millennia. They could cause serious and destructive effects on human society and infrastructure as well as on ecosystems and wildlife. Consequently, they are usually the main center of attention of the news media in reports on climate. There are some indications from observations concerning how climatic extremes may have changed in the past. These observed and modeled changes relate directly to the understanding of socioeconomic and ecological impacts related to extremes [3]. Exposure to waterborne and foodborne pathogens can happen via drinking water that is connected with fecal contamination, seafood (due to natural microbial hazards, toxins, or wastewater disposal) or fresh produce (irrigated or processed with contaminated water) [5]. Weather affects the transport and distribution of these microbial agents via rainfall and runoff and the main key for the survival or growth through such issues is temperature [5]. According to the CDC, food borne diseases are responsible for about 76 million cases of disease, with 325,000 hospitalizations and 5,000 deaths in the U.S. every year. Water borne diseases are responsible for about 9 million cases of disease every year in the US [3].

**Introduction**

Many studies of weather and climate extremes agree with the insights from our understanding of how the climate system works. For example, a warming of the surface supplies more water vapor to the atmosphere, thus making it more moisture available to storms [4]. It is consequently expected an increase of powerful precipitation and more rainfall from a particular storm. Both results are seen in climate model simulations [4].

Moreover, a number of changes in weather and climate extremes from climate models have been seen in observations in various parts of the world (decreased diurnal temperature range, warmer mean temperatures associated with increased very warm days and decreased very cold days, increased rainfall intensity, etc.) [4].

In 1996, Kattenberg et al. studies have reproduced some results reported by the Intergovernmental Panel on Climate Change (IPCC). Their conclusions are as follows [4]:

1) An increase in mean temperatures leads to more extreme high temperatures and less extreme low temperatures.

2) Nighttime low temperatures in many regions increase more than daytime highs, thus reducing the diurnal temperature range.

3) Decreased daily variability of temperature in winter and increased variability in summer in Northern Hemisphere mid-latitude areas significantly modify changes in extremes.

4) Increased moisture content in many regions contributes to increased precipitation intensity.

5) Indian monsoon variability tends to increase, thus increasing the chances of extreme dry and wet monsoon seasons.

6) There is a general drying of the mid-continental areas during summer with increased chance of drought. This is ascribed to a combination of increased temperature and decreased precipitation.

7) Several global climate models indicate that the future mean Pacific climate base state could more resemble an El Niño–like state (i.e., a slackened west–east SST gradient with associated eastward shifts of precipitation), though that result remains model dependent. For such an El Niño–like climate change, future seasonal precipitation extremes associated with a given El Niño would be more intense due to the more El Niño–like mean base state.

**Discussion**

Climate Change will impact human health in five key ways. **E** coli, Cryptosporidium and other Water and Food Borne Diseases; **A**ir Pollution; **R**odents, Insect and Tick Borne Disease; **T**emperature Extremes; **H**urricanes, Storms and Severe Weather Disasters[3]. My paper will focus mainly on Water and foodborne diseases that might link to the others.

Climate, directly impacts the occurrence of waterborne disease through effects on water temperature and precipitation frequency and intensity [1]. Rainfall and runoff, have been associated in site-specific water borne outbreaks. Because upward trends in heavy precipitation in the United States are expected to increase with climate change, my study is focusing on quantifying the relationship between precipitation, other extreme weather events and disease outbreaks [2]. Furthermore, outbreaks of *Escherichia coli*, is usually considered a foodborne pathogen, has been associated to rainfall events [2]. A waterborne disease outbreak is defined as an outbreak in which epidemiologic evidence points to a drinking water source from which two or more persons become ill at similar times [2].

The effects of these waterborne and foodborne diseases, are pathogen and pollutant specific, and risks for human disease are distinctly affected by local conditions, including regional water and sewage treatment capacities and practices [1]. Domestic water treatment plants may be susceptible to climate change leading to human health risks. For example, droughts may cause problems with increased concentrations of sewage pathogens and overcome water treatment plants [1].

**Figure 1:** Potential waterborne and foodbornea diseases. **a**Foodborne diseases primarily related to marine or freshwater contamination. **b**Moderating influences include nonclimate factors that effect climate-related health outcomes, such as state of coastal wetlands, land use, and water treatment facilities. **c**Finished drinking water must meet higher regulatory standards than recreational water or water used for irrigation. **d**Adaptation measures include actions to reduce risks of water contamination, such as watershed management, improved water treatment engineering, and enhanced surveillance of waterborne disease outbreaks.

**Montana USA (1980):** There was a waterborne outbreak of giardiasis associated with heavy rainfall. The episode started from mid-June through early August 1980. It was an outbreak of gastrointestinal illness in Red Lodge, Montana that affected approximately 780 persons [6].

The Red Lodge population was distributed in two areas: 1,873 persons belonged within the compact city limits, and 1,087 persons lived in rural areas within 10 km of Red Lodge. The main source of the city's water was West Fork Rock Creek, which drained surface runoff from snow in the watershed of the Absaroka Range of the Rocky Mountains west of Red Lodge. The water system served an area that coincided almost exactly with the city limits [6].

The vehicle transmission in this outbreak was the city’s water supply system [6]. However, what have triggered the unusually heavy water runoff that most possibly led to infection of the city water system, was the rare combination of warm sunny days and the increased absorption of heat by the darkened ash-covered snowfields of the watershed [6].

 During the outbreak, the drinking water of the whole city had been unfiltered. The water came from chlorinated surface water from an exposed watershed with several probable sources of contamination, such as overflow from septic tanks, and the presence of hikers, campers, and wildlife. Beavers, dogs, and cattle, as well as other animals that probably inhabit the Red Lodge watershed, may be infected with *Giardia*, and act as a reservoir of the disease [6].

In late 1982 the city stopped using surface water from West Ford Rock Creek and began providing well water pumped to a new reservoir. Water meters were installed to reassure protection of the limited supply of well water. There was also in the plan to build a filtration system for the more abundant surface water from West Fork Rock Creek because that source was not considered sufficient for fire-fighting or the future growth of the town [6].

Water systems analogous to the one involved in this outbreak that was using unfiltered surface water appear more likely to become contaminated during periods of heavy runoff. The equipment and operation of many of these systems in the US was similar to the Red Lodge system during the outbreak. Operators of such systems in areas where *Giardia* infection may occur should be alert of the risk during heavy runoff, at which time the public might be advised to boil tapwater or use an appropriate alternate source of drinking water [6].

**Milwaukee USA (1993):** Waterborne outbreak of cryptosporidiosis associated with heavy rainfall and run-off. The massive outbreak occurred in the greater Milwaukee are during late March and early April in 1993. It was estimated that more than 40,000 people were affected [7]. *Cryptosporidium* infection was confirmed in more than 600 people with gastrointestinal illness in association with this outbreak [7].

Even though the United States is believed to have high-quality drinking water, the risk of pollution from leaking septic tanks or agricultural runoff remains. One pathogen, Cryptosporidium, a protozoan that completes its life cycle within the intestine of mammals, is shed in high numbers of infectious oocysts that are distributed in feces. It is highly prevalent in ruminants and readily transmitted to humans [2].

*Cryptosporidium* oocysts in untreated water from Lake Michigan probably entered the southern water-treatment plant and were then incompetently removed by the coagulation and filtration process. *Cryptosporidium* oocysts have often been found in untreated surface water used for public water supplies in the United States [7]. The cause of the oocysts leading to the outbreak in Milwaukee and the timing of their entrance into Lake Michigan remains hypothetical. Possible sources though include cattle along two rivers that flow into the Milwaukee harbor, slaughterhouses, and human sewage. Rivers that were swelled by spring rains and snow runoff may have transported oocysts into Lake Michigan of the Milwaukee Water Works southern plant [7].

**New York State, USA (1999):** Waterborne outbreak of *E.coli O157:H7* related to heavy rainfall. The largest reported outbreak of waterborne Escherichia coli O157:H7 in the United States occurred in upstate New York following a county fair in August 1999.

This outbreak, which included 775 patients with suspected cases of infection, was the largest outbreak of diarrhea associated with waterborne E. coli O157:H7 ever reported in the United States [8].

*Escherichia coli O157:H7* is a main cause of severe and bloody diarrhea. The outbreak was recognized when the Bureau of Communicable Disease Control of the New York State Department of Health became aware of an increased number of persons being assessed for diarrheal illness at local hospitals. Hospitalized children showed deteriorating kidney function, and *E. coli* O157:H7 was isolated from the stool of one patient. The next day, area hospitals were alerted to consider *E. coli* O157:H7 infection in patients who presented with diarrheal illness [8].

Cases of diarrheal illness among fair attendees have been reported from 14 New York counties and four states [9]. An environmental investigation of the fairgrounds on the 3rd of September showed that much of the fair was supplied with chlorinated water. Therefore, in at least one area of the fair, a shallow well supplied water that was not chlorinated to several food vendors who used the water to make beverages and ice. Initial cultures of water from this well generated high levels of coliforms and *E. coli* [9]. Heavy rains that followed a period of drought overlapped with this major outbreak event. The likelihood of this type of problem occurring may be increased under conditions of high soil saturation, which growths rapid transport of microbial organisms [10].

**Florida (1997 – 1998):** Human enteroviruses; greater faecal contamination of waters and shellfish associated with heavy rainfall caused by El Niño.

Runoff from rainfall is a key factor in pollution of coastal waters and shellfish harvesting areas. A year-long microbiologic survey of a southwest Florida estuary (Charlotte Harbor) showed that the concentrations of fecal indicator organisms during winter of the high-precipitation El Niño of 1997/1998 were many fold greater than were the concentrations found throughout the rest of the year [10]. During that period, infectious enteroviruses were detected at 75% of the sites sampled, whereas in previous months no viruses were found. Viruses were identified in open shellfish harvesting areas during this increase in rainfall. Antecedent rainfall anticipated the presence of enteroviruses one week later. Similarly, fecal indicators were significantly correlated with rainfall [10].

**Alaskan Waters (2004):** Outbreak of *Vibrio parahaemolycitus* that affected 62 passengers on a cruise ship. On July 16, 2004, the DEC notified the Alaska Section of Epidemiology of several cases of gastroenteritis among passengers on a cruise ship (78-passenger capacity) that was sailing in Prince William Sound [11].

*Vibrio parahaemolyticus*, is the leading cause of seafood-associated gastroenteritis in the United States. It is typically associated with the consumption of raw oysters gathered from warm-water estuaries [12]. Before the summer of 2004, Alaskan waters were thought to be too cold to support levels of *V. parahaemolyticus* high enough to cause disease.

Findings of the report of the New England journal of Medicine confirmed the hypothesis that a water temperature above 15.0°C at the time of oyster harvest is an appropriate threshold indicator of increased risk of *V. parahaemolyticus* infection from the consumption of raw oysters [12]. Although water temperatures have reached 15.0°C at Farm A each year since 1997, 2004 was unusual because mean temperatures were above 15.0°C for a much longer period and were almost 2°C warmer than during any of the previous years [12].



**Conclusions**

The U.S. is likely to experience increases in extreme cold, extreme heat, hurricanes, floods, wildfires, droughts, tornadoes and severe storms. Researchers expect that climate change will increase the severity, frequency, timing, and duration of extreme weather events, which in turn will increase health risks. The Midwest is mainly susceptible to increasingly severe storms, extreme heat events, tornadoes, and flooding [13]. Tornadoes and floods could lead to increased injuries and death, but, these disasters can also lead to indirect threats to human health during a community’s recovery period. Some of these threats include increased infectious disease risk, increases in disease-causing molds and fungi in homes and buildings, and decreases in water quality (*Cryptosporidiasis*, *salmonellosis*, *E.coli* infections) [13]. These diseases could occur when water structure such as treatment systems and storm water collection is compromised [13].

In the United States more than 200 million people have direct access to uncontaminated public water supply systems. However, as many as 9 million cases of waterborne disease are estimated to occur each year [13]. Measuring the present threat of waterborne disease in the United States is difficult by the fact that many cases of waterborne disease, typically, gastrointestinal illness, go unreported.

Additionally to heat waves, power outages, often a result of extreme weather may cause increases in foodborne illnesses. When power outages occur during extreme weather events, food spoils easily, and foodborne illnesses may result [13]. Despite the under-reporting, epidemiologists have determined that there are approximately 76 million cases of foodborne illnesses in the U.S. each year, resulting in approximately 5000 deaths. Of the cases reported, 67% of cases are due to viruses (primarily noroviruses), 30% to bacteria (primarily Campylobacter and Salmonella) and 3% to parasites (primarily Giardia and Cryptosporidium) [13].

Climate change may perhaps be increasing the range of pathogen spreading, which could increase the number of food-borne pathogens in a given region. The most commonly mentioned incidence is that of the outbreak of shellfish-associated *Vibrio parahaemolyticus* in Prince William Sound in Alaska [13].

Likewise, there is strong evidence that increasing global temperatures will increase rates of salmonellosis. In Illinois between 2009 and 2010, the stated cases of *Salmonella* rose from 1,484 to 1,982 cases, a 34% increase. *E. coli* increased from 124 cases in 2009 to 156 cases in 2010. *Salmonella* and other pathogens adapted to growing under low nutrient and warm temperature conditions are likely to increase in numbers with climate change, and the diseases associated with theses pathogens are also likely to increase [13].

Climate change affects water resources in several ways. Some areas face water shortages while other areas experience flooding. Water shortages are predicted to occur throughout the U.S. due to increases in water demand, decreases in snowmelt, and drought. Droughts will increase water temperatures and will promote algal and microbial growth. Powerful precipitation could lead to higher runoff rates and higher levels of water contamination. Waterborne illnesses such as *legionellosis* from exposure to pathogenic microorganisms and chemically contaminated drinking water and could become more prevalent [13].

Every government’s concern should be to decrease global greenhouse gas emissions at international, federal, state, and local levels. Also, 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 diseases [14].Finally, if passage of strong legislation that sets limits on global warming pollution and directs investments toward clean energy technologies is established, this will provide double benefit of helping to protect water supplies, global health and the world would be a much better place for us and our children to leave in.

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