

# THE PUBLIC HEALTH RISKS OF INADEQUATE WASTEWATER TREATMENT

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According to the Gates Foundation (Bill and Melinda Gates Foundation, 2019), “[a]bout 4.5 billion people—more than half the world’s population—either practice open defecation or use unsafe sanitation facilities and services... causing more than 1200 deaths in children under five-years-old per day, more than AIDS, measles, and tuberculosis combined, ...more than half a million deaths from diarrhea alone, in 2016.”

To be effective, sanitation must be carefully managed at all stages, from the point that waste is collected and contained to how it is transported and treated. If there are gaps or breaks at any stage, then harmful human waste flows into surface waters and fields where children play and people of all ages live, eat, drink and bathe. (Bill and Melinda Gates Foundation, 2019)

Fortunately, in the United States, we currently see little direct evidence of these hazards. In the urban, densely populated parts of the country, approximately 75% of Americans are served by excellent municipal wastewater utilities coupled with excellent municipal drinking water utilities, as determined from the lack of major disease outbreaks. For the 25% of Americans living in the rural, sparsely populated regions of the country, distance, safety factors, and the lack of a disease carrier combine to minimize the public health risks of systems often not well-maintained.

However, the US has experienced waterborne disease outbreaks in the past and the lack of waterborne problems may be leading Americans to ignore the threats inherent in a lack of wastewater solutions for some Americans.

This paper will explore the public health risks of inadequate wastewater treatment, including some historical outbreaks as well as some emerging threats. Controlling contagious disease requires constant monitoring and adjustment to assure that previous threats remain under control and to assure that threats posed by emerging pathogens are addressed through treatment technologies or, sometimes, through education and social programs.

In Virginia, the State Health Commissioner in 1992, Robert Stroube, issued GMP (Guidance Memoranda and Policy) 1992-01 entitled “Environmental Health Considerations of Sewage”. In this policy, Dr. Stroube lists several pathogens or groups of pathogens of particular concern in operating the onsite sewage program in Virginia:

- Salmonellosis
- Shigellosis
- Sporadic viral gastroenteritis
- Epidemic viral gastroenteritis
- Amebiasis
- Cholera

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- Viral hepatitis A

(Robert B. Stroube, 1992)

The Centers for Disease Control and Prevention lists some of the same pathogens along with specific amoebic and protozoan pathogens on their website: “amebiasis, cryptosporidiosis, giardiasis, cholera (non-laboratory), shigellosis (non-laboratory), and infections caused by Cronobacter (non-laboratory), enterotoxigenic E. coli (ETEC; non-laboratory), and the free-living amoebae Acanthamoeba, Balamuthia, Naegleria, and Sappinia” (Centers for Disease Control and Prevention, 2019).

We see outbreaks from these diseases rarely today in the US, however some of these pathogens caused outbreaks not too far in the past and some are currently causing outbreaks today in isolated locations. Without consistent diligence and attention, we could see some of these pathogens rise to prominence again.

### **Salmonellosis**

“A bacterial disease commonly manifested by an acute enterocolitis, with sudden onset of headache, abdominal pain, diarrhea, nausea and sometimes vomiting. Dehydration may be severe, especially among infants. Deaths are ordinarily uncommon except in the case of the very young, the very old, or the debilitated. The disease is transmitted by eating food from infected food animals or food contaminated by the feces of an infected animal or person, or by drinking water contaminated by the feces of an infected animal or person.” (Robert B. Stroube, 1992)

*Salmonella typhi* is a species from the salmonella group of bacteria that has caused numerous outbreaks in the US. “Typhoid Mary” is an infamous historical character that was an asymptomatic carrier of the typhoid fever at the turn of the century in New York City (Singer, August). Mary Mallon served as a cook for a number of affluent families, all of whom suffered typhoid fever outbreaks with several deaths.

Even when those suffering from typhoid fever receive modern antibiotics, a small number will continue to harbor the bacteria in their intestinal tract and can continue to shed the bacteria in their stool for years (Mayo Clinic).

### **Shigellosis**

“An acute bacterial disease involving the large and small intestines, characterized by diarrhea accompanied by fever, nausea and sometimes toxemia, vomiting, cramps and tenesmus. Convulsions may be an important complication in young children. The severity of illness and the possibility of death depend on the age and pre-existing nutritional state of the host, the size of the infecting dose and the serotype of the organism. The disease is transmitted by direct or indirect fecal-oral transmission from a patient or carrier. Infection may occur after the ingestion of very few organisms. Cockroach and flyborne transmission may occur as the result of direct fecal contamination.” (Robert B. Stroube, 1992)

*Shigella dysenteriae*

“Twice as many Civil War soldiers died from disease as from battle wounds, the result in considerable measure of poor sanitation in an era that created mass armies that did not yet understand the transmission of infectious diseases like typhoid, typhus, and dysentery.” (Faust) Faust states that the number of American fatalities has generally been estimated at 620,000, equivalent to the number of deaths in all American wars through the Korean conflict. The number of soldier deaths, 620,000, is equivalent to approximately 2% of the population of the country at the time. (At the current population of the US, 2% of the population would equal approximately 6 million people.) One historian estimates civilian deaths at about 50,000, largely from infectious disease and starvation.

### **Viral gastroenteritis**

“**Sporadic severe gastroenteritis** in infants and young children is characterized by diarrhea and vomiting, often with severe dehydration and occasional deaths in the younger age groups. Milder forms of gastroenteritis can also occur. While the disease's mode of transmission is not exactly known, it is thought to probably be fecal-oral and possibly fecal-respiratory. “ (Robert B. Stroube, 1992)

“**Epidemic viral gastroenteritis** - A usually selflimited mild disease that often occurs in outbreaks with clinical symptoms of nausea, vomiting, diarrhea, abdominal pain, myalgia, headache, malaise, low-grade fever or a combination of these symptoms. Gastrointestinal symptoms characteristically last 24 to 48 hours. Again, it is believed that the transmission of the disease probably occurs by the fecal-oral route.” (Robert B. Stroube, 1992)

Treatments available for viral diseases are limited. Doctors can prescribe antibiotics for bacterial infections, however when the principal cause of a disease is viral, antibiotics are only useful for secondary infections caused by bacteria.

### **Amebiasis**

“This results from infection by a protozoa [or amoeba]. Most infections are asymptomatic, but may become clinically important under certain circumstances. Intestinal disease varies from acute or fulminating dysentery with fever, chills, and bloody or mucoid diarrhea (amebic dysentery), to mild discomfort with diarrhea containing blood or mucous alternating with periods of constipation or remission. Epidemic outbreaks result mainly from ingestion, or fecally contaminated water containing amebic cysts. Epidemic spread is by hand-to-mouth transfer of feces.” (Robert B. Stroube, 1992)

The Milwaukee outbreak of cryptosporidiosis in 1993 is a truly notable outbreak of waterborne crypto. Over 403,000 people became infected. Investigators were later able to use ice from a factory in southern Milwaukee to track the progress of the water conditions leading to the outbreak. Even though the water plant was in full compliance with operating standards of the time, the turbidity of the water increased significantly and filtration failed to remove the crypto spores. (Mac Kenzie, 1994)

*Giardia lamblia* and, as noted previously, *Acanthamoeba*, *Balamuthia*, *Naegleria*, and *Sappinia*, are additional amoebic pathogens that can cause waterborne disease outbreaks.

## **Cholera**

“An acute bacterial enteric disease with sudden onset, profuse watery stools, occasional vomiting, rapid dehydration, acidosis and circulatory collapse. Mild cases with only diarrhea are common, especially among children. Death may occur in severe, untreated cases within a few hours and the case fatality rate in such cases may exceed 50%. With proper treatment, the death rate is below 1%. The ways the disease may be transmitted include drinking water contaminated with feces of patients, or, to a lesser extent, feces of carriers, or eating food which has been contaminated by feces. Raw or undercooked seafood from polluted waters has been the cause of several cholera epidemics.” (Robert B. Stroube, 1992)

*Vibrio cholera* is diabolical because the “tail” of the organism is actually a pilus that the organism uses to harpoon pieces of DNA from other microorganisms and then incorporates into its own DNA. By changing its DNA, the organism becomes resistant to both natural and medical attempts to combat its spread. (Hammer, 2018)

Cholera can be mild in some people, but at its worst causes a diarrhea so profound that patients lose a quart of fluid per hour, quickly becoming dangerously dehydrated. Cholera beds have a hole under the patient where a bucket can be placed to remove the waste and treatment consists largely of replacing vital fluids as quickly as possible to support the patient.

Dr. John Snow is considered the father of modern epidemiology (and possibly also geographic information systems (GIS)) because he plotted cases of cholera on a map during an outbreak of cholera in London in 1854 and was able to determine that a pump providing water from the Thames was the source of the outbreak. He interrupted the progress of the outbreak by convincing officials to disable the pump.

While cholera can spread into a devastating outbreak, it is also highly preventable. Modern water and wastewater treatment can stop the spread of the disease easily.

## **Viral hepatitis A**

“This is characterized by abrupt onset with fever, malaise, anorexia, nausea and abdominal discomfort, followed within a few days by jaundice. The effects vary [sic] from a mild illness lasting one to two weeks to a more rare, and severely disabling disease lasting several months. In general, severity increases with age, but complete recovery is the rule. The disease is transmitted person-to-person by the fecal-oral route. The infectious agent is found in feces, reaching peak levels the week or two before the onset of symptoms appear, concurrent with the appearance of circulating antibodies. The disease is most common among school-age children and young adults.” (Robert B. Stroube, 1992)

When there is an outbreak of Hep A in a restaurant or a jail, etc., all the EHSs and many of the nurses in a health district are assigned to help interview the staff to determine the carrier and

everyone's exposure level as quickly as possible. The restaurant will be closed until they get a handle on the exposures.

In the US when outbreaks occur, the source is often a contaminated food item. However, CDC notes an increasing risk in homeless populations. Often IV drug users and men who have sex with men are included in these statistics, but the number affected who have only homelessness as a risk factor is significant. (Foster M, 2018)

## **OTHER DISEASES**

The diseases discussed so far are the ones we traditionally find associated with wastewater. In recent years, other diseases have found to be associated with inadequate wastewater treatment, as well. There is currently little data comparing disease rates between US homes connected to municipal facilities and homes using onsite sewage systems due to the dropping of the question about onsite sewage treatment by the US Census in 1990, however, recent achievements by the National Onsite Wastewater Recycling Association (NOWRA) promise to make the data more accessible in the future.

### **Hookworm**

Hookworm is a tropical parasite that was prevalent in the US in the early 1900's. (Pilkington, 2017) The disease has long thought to be eradicated in the US, but a study conducted in Alabama by Baylor University has shown that the disease has made a comeback. Catherine Flowers, an activist based in Lowndes Co., Alabama, has been instrumental in bringing attention to the recurrence of this disease.

The disease is caused by a parasite that attaches to the small intestine of the patient. "Over months or years it causes iron deficiency and anemia, weight loss, tiredness and impaired mental function, especially in children, helping to trap them into the poverty in which the disease flourishes." (Pilkington, 2017).

In Lowndes County, many homes of low-income residents have inadequate wastewater facilities due to poor soils. Installing onsite wastewater systems in these soils would require expensive treatment systems to work properly and the residents cannot afford them. Many homes have straight pipes that discharge on the ground surface, causing conditions that allow the spread of hookworm through the soles of the feet of the residents.

### **Respiratory disease**

Some especially intriguing data comes out of rural Alaska where both running water and wastewater facilities are challenging due to permafrost and extreme cold. Public health officials did some studies in these rural communities and found that "children living in homes without running water were 10 times more likely to have viral pneumonia, severe bacterial infections, or skin infections. Adults also living without running water were more likely to have pneumonia and influenza and skin infections like boils." (Alaska Department of Environmental Conservation, 2016).

Respiratory disease is not commonly associated with a waterborne source. The route of transmission could be aerosol in these rural homes without running water. In either case, while Alaska's conditions are extreme, future census data may allow us to make further correlations in disease occurrence among homes with adequate vs inadequate wastewater facilities, leading us to more data on causation.

## **CONCLUSION**

In modern America the threat of huge waterborne disease outbreaks seems to be remote. Most Americans don't even know which of the "famous" pathogens can be waterborne. But there are some warning signs that waterborne disease could make a comeback, even in the US.

Of the outbreaks covered in this paper so far, a few occurred in modern times. The Milwaukee crypto outbreak occurred in 1993. The hookworm cases in Alabama are ongoing, as are the cases of respiratory disease associated with inadequate wastewater facilities in Alaska.

There are other modern waterborne outbreaks that should cause us concern.

California is one of the states experiencing a surge in homelessness among its population due to the extreme cost of housing in its metropolitan areas (Hoffower, 2018). Some of the homeless are living in cars and vans, and some in large camps outside of the cities.

In San Diego, 14 people died in an outbreak of Hepatitis A (Davis, 2017). Seventy percent of the 264 people hospitalized were homeless. Investigators believe that the original source of the outbreak was foodborne, but then the disease spread through various other means due to lack of handwashing facilities among the homeless population.

In Haiti following a devastating earthquake and subsequent hurricane, an outbreak of cholera raged through the island nation. The organism is endemic in parts of the world and can be transmitted by asymptomatic carriers as was likely the case in the Haitian outbreak that began in 2010. Investigators believe that the outbreak began when two asymptomatic aid workers from Indonesia used restrooms that discharged into a lagoon with no wastewater treatment. The wastewater discharged into the Arbonite River and the outbreak spread quickly throughout the island. "An estimated 3 million people were affected and the death toll was between 80,000 and 270,000, depending on who was doing the counting." (Frerichs, 2016)

We know from the resurgence of contagious diseases like the measles that we must maintain education and outreach programs to combat contagious disease. Measles is not a waterborne disease and the increased number of cases is due to parents' opting out of vaccines for their children. Since worldwide vaccine programs had been so successful in limiting the spread of measles, many parents assumed that opting out of the vaccine was safe for their children since the likelihood of contracting the disease seemed so remote.

In modern America, the likelihood of waterborne disease seems remote also.

We know that the Social Determinants of Health play a big factor in the health of the population. Low income by itself causes health issues that cross the boundaries of race and ethnicity. Simple handwashing is a major preventative measure in the spread of most diseases. Does a family experiencing problems with their septic system wash their hands as often as they should?

Approximately 25% of US single family homes rely on onsite wastewater for their sewage utility and for the most part, these folks are on their own to finance a solution if their wastewater system fails. A recent poll by NPR found that: “A substantial number (40%) of rural Americans struggle with routine medical bills, food and housing. And about half (49%) say they could not afford to pay an unexpected \$1,000 expense of any type,” (Neel, 2019) and we all know even most simple repair of a conventional onsite wastewater system is likely to cost more than \$1000.

For the 75% of Americans that live within the reach of public sewer, resources are available through the utility or municipality to help them connect. The 25% of Americans outside those bounds may need some help also.

The technology to provide superior wastewater treatment in areas where public sewer is not available is readily available through the use of onsite sewage systems, also called decentralized sewage systems. These technologies could provide a solution to improve wastewater sanitation in homeless camps and for deployment of aid workers and military units, preventing outbreaks such as the cholera outbreak in Haiti and the hepatitis outbreak in San Diego.

For the 25% of Americans that rely on decentralized sewage solutions, especially those with low-to-moderate income, how much of what we currently call the “social determinants of health” is due to inadequate wastewater treatment? The respiratory illness and hookworm studies in Alaska and Alabama respectively are limited but alarming. As better data become available for this sector through NOWRA’s efforts and public health agencies, what additional correlations will we find? Public funding streams have been highly effective at eliminating widespread disease outbreaks where municipal facilities are possible. We already have the technology to address decentralized wastewater challenges. The time has come to find ways to assure that these technologies are available to those who need them.

## References

- Alaska Department of Environmental Conservation. (2016). *Alaska Department of Environmental Conservation; Division of Water*. Retrieved from Alaska Water and Sewer Challenge: <https://dec.alaska.gov/water/water-sewer-challenge/>
- Bill and Melinda Gates Foundation. (2019, July 12). *Water, Sanitation & Hygiene*. Retrieved from Bill and Melinda Gates Foundation: <https://www.gatesfoundation.org/what-we-do/global-growth-and-opportunity/water-sanitation-and-hygiene>
- Centers for Disease Control and Prevention. (2019, April 24). *Division of Foodborne, Waterborne, and Environmental Diseases (DFWED)*. Retrieved 08 14, 2019, from Waterborne Disease Prevention Branch: <https://www.cdc.gov/ncezid/dfwed/waterborne/index.html>
- Davis, K. (2017, August 28). *Deadliest outbreak of hepatitis A in decades kills 14 in San Diego*. Retrieved from The Guardian: Outside in America: Homelessness: <https://www.theguardian.com/us-news/2017/aug/28/hepatitis-a-san-diego-deaths>

- Faust, D. G. (n.d.). *Civil War Era National Cemeteries: Honoring Those Who Served; National Park Service*. Retrieved August 16, 2019, from Death and Dying: [https://www.nps.gov/nr/travel/national\\_cemeteries/Death.html](https://www.nps.gov/nr/travel/national_cemeteries/Death.html)
- Foster M, R. S. (2018). Hepatitis A Virus Outbreaks Associated with Drug Use and Homelessness — California, Kentucky, Michigan, and Utah, 2017. *MMWR Morb Mortal Wkly Rep*, 67:1208–1210. doi:<http://dx.doi.org/10.15585/mmwr.mm6743a3>
- Frerichs, R. R. (2016). *Deadly River: Cholera and Cover-Up in Post-Earthquake Haiti*. Ithaca and London: ILR Press, an imprint of Cornell University Press.
- Hammer, A. (2018, June 21). *Watch This Bacterium Use a Tiny Tentacle to Harpoon DNA*. Retrieved September 22, 2018, from [www.curiosity.com](http://www.curiosity.com)-Science and Technology: [https://curiosity.com/topics/watch-this-bacterium-use-a-tiny-tentacle-to-harpoon-dna-curiosity?utm\\_source=androidapp](https://curiosity.com/topics/watch-this-bacterium-use-a-tiny-tentacle-to-harpoon-dna-curiosity?utm_source=androidapp)
- Hoffower, H. (2018, August 21). *California real estate is so expensive that families, retirees, and even tech workers are living in cars and vans*. Retrieved from Business Insider: <https://www.businessinsider.com/california-housing-so-expensive-people-live-in-cars-vans-2018-8>
- Mac Kenzie, W. R. (1994). A Massive Outbreak in Milwaukee of Cryptosporidium Infection Transmitted through the Public Water Supply. *New Englan Journal of Medicine*, 331(3), 161-168.
- Mayo Clinic. (n.d.). *mayoclinic.org*. Retrieved August 14, 2019, from Typhoid Fever: <https://www.mayoclinic.org/diseases-conditions/typhoid-fever/symptoms-causes/syc-20378661>
- Neel, J. a. (2019, May 21). *Poll: Many Rural Americans Struggle With Financial Insecurity, Access To Health Care*. Retrieved from Shots: Health News from NPR: <https://www.npr.org/sections/health-shots/2019/05/21/725059882/poll-many-rural-americans-struggle-with-financial-insecurity-access-to-health-ca>
- Pilkington, E. (2017, September 5). Hookworm, a disease of extreme poverty, is thriving in the US south. Why? *The Guardian*.
- Robert B. Stroube, M. M. (1992, September 4). *Virginia Department of Health Onsite Sewage and Water Services, Environmental Engineering, and Marina Programs*. Retrieved August 14, 2019, from Guidance Memoranda and Policies: <http://www.vdh.virginia.gov/content/uploads/sites/20/2016/05/GMP-002-glh.pdf>
- Singer, E. (August, 31 2016). *Quanta Magazine*. Retrieved August 2019, from The Strange Case of Typhoid Mary: <https://www.quantamagazine.org/why-typhoid-mary-never-got-sick-20160831/>