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WATER WOES: OPPORTUNITIES FOR WATERBORNE PATHOGENS TO CAUSE ILLNESS

Those "very little animalcules" he was able to isolate from different sources, such as rainwater, pond and well water, and the human mouth and intestine.

Antonie van Leeuwenhoek
– inventor of the microscope

SANITATION CHALLENGES

Although pandemics of cholera and typhoid fever are in the rearview mirror due to public health measures for sanitation and hygiene, these conditions still plague citizens of lower-income countries. Outbreaks associated with public water systems have sharply declined, however waterborne illnesses are still contracted through consumption of water from private wells or unregulated water systems. Water systems also must be appropriately maintained to ensure disinfection from waterborne pathogens. Stagnant water in pipes, long water-retention times reducing disinfectant contact time, and inadequate hot water temperatures are conducive to the formation of biofilms, a multi-pathogen matrix that forms on any surface available to bacteria or amoebae, protecting the inhabitants from many disinfectants routinely used in plumbing pipes, tubes, hot tubs, cooling towers, or medical equipment. Some of these pathogens are a challenge to eradicate from the miles of pipes in hospitals, hotels, and apartment buildings, resulting in outbreaks of infection by *Legionella*, *Pseudomonas*, *Naegeleria fowleri*, and nontuberculous mycobacteria (NTM). Water is an ideal growing environment for pathogens that can spawn numerous types of infections – mild or severe respiratory illness, gastrointestinal distress, skin and soft tissue infections, and even meningitis.

Over time, humans' use of water has become more complex, resulting in opportunities for these pathogens to proliferate and cause illness. Water is used in many medical procedures and devices, industrial processes, and daily hygiene practices.

CHLORINATED PUBLIC POOLING

With more time for recreation and travel come additional risks for waterborne illness, despite the use of chlorine. Swimming pools, waterparks, splash pads, hot tubs, and other recreational water activities such as water skiing, indoor kayak training, and "survivor"-type competitions raise the risk of waterborne infections. Most treated-water venues such as hot tubs and swimming pools use chlorine to prevent pathogen survival, but the chlorine levels need to be checked and maintained on a regular basis. Organic matter can absorb the chlorine, and sunlight can denature it, so routine testing of free-chlorine levels is of value. When systems are not maintained, opportunistic waterborne pathogens can bloom. Illnesses can be gastrointestinal, respiratory, neurologic, skin (i.e., wound infection), ear, and eye illness.

NAEGLERIA: NOW NORTHER

Naegleria fowleri, a warm-water, brain-eating amoeba that causes primary amoebic meningoencephalitis (PAM), has in recent years infected people as far north as Minnesota. Cases have been associated with use of sinus-cleansing neti pots, slip and slides, a hot-spring-fed swimming pool, and an indoor kayak training center. Most *Naegleria* infections are fatal and diagnosed only at autopsy. Recent cases in Texas occurred during the summer months in visitors to splash pads where improper water-feature maintenance was identified during the epi investigation.

Persons presenting with PAM often test negative for more common bacterial or viral causes of meningitis. However, these amoebae can be seen on a wet mount microscopic exam of fresh cerebrospinal fluid. Confirmatory testing is available at the Centers for Disease Control and Prevention (CDC). Assessing a patient for recent water exposures, especially activities that might aerosolize water, is important for identifying PAM.

…AND ANOTHER AMOEBA

Since amoebic infections of the central nervous system became reportable in Oregon in 2015, two fatal *Acanthamoeba* infections have been reported here; both were in homeless persons. Found worldwide in the environment in water and soil, *Acanthamoeba* can be spread to the eyes through contact lens use. It can also gain a foothold through cuts or other skin wounds, or by being inhaled into the lungs. Most people are exposed to *Acanthamoeba* during their lifetime, but illness is rare. Symptoms vary based on route of entry. The most serious manifestation—granulomatous encephalitis—is associated with headache, nausea and vomiting, seizures, and hallucinations. These progress over several weeks and often result in death. Testing at CDC is available for diagnosis and speciation.

MYSTERIES OF *MYCOBACTERIUM*

In 2014 extrapulmonary nontuberculous *Mycobacterium* (NTM) infections became reportable in Oregon. More than 100 species of NTM live in water and soil, and infections can present in numerous ways, with cutaneous, joint, bone, soft-tissue and central nervous system manifestations. Soft-tissue infections result in purple

Figure 1. Incidence of extrapulmonary nontuberculosis mycobacterial (NTM) disease Oregon, 2014–2020. NTM became reportable in 2014

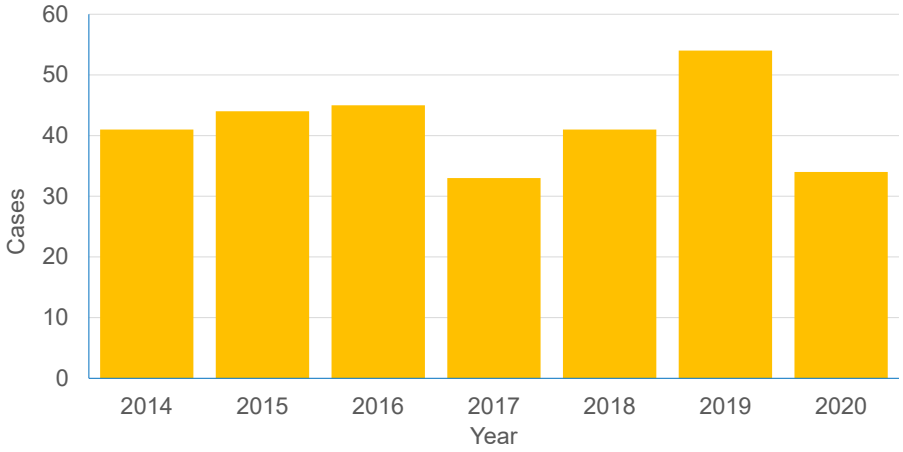
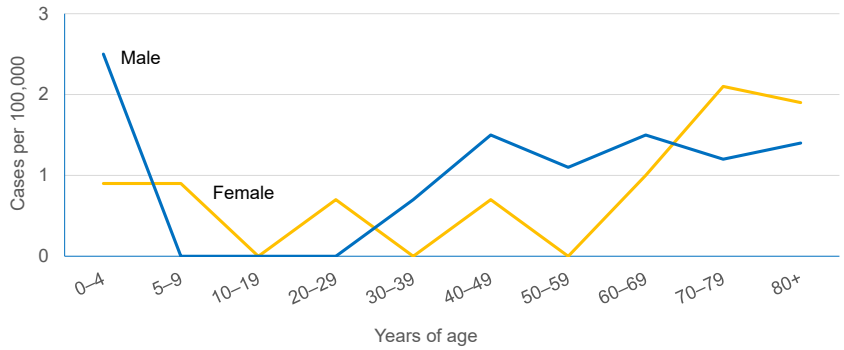


Figure 2. Incidence of extrapulmonary nontuberculous mycobacterial disease (NTM) by age and sex: Oregon, 2020



nodules that drain and can ulcerate or form scars. Disease-causing mycobacterial species frequently identified in the United States include *M. avium* complex (MAC), *M. marinum*, *M. abscessus*, *M. chelonae*, *M. fortuitum*, *M. kansasii* and *M. xenopi* (in certain regions). Cutaneous lesions result from trauma, medical procedures, whirlpool exposure, nail salons, and tattoo parlors. Disseminated disease mostly develops in immunocompromised patients and can be a challenge to treat. Three hundred thirty-one cases were reported during 2014–2021 (Figure 1). The highest rates of infection in Oregon occur among mostly immunocompetent children <5 years of age, presenting as lymphadenitis (Figure 2). Children in this age group typically bring contaminated items into their mouths, and infection of the oropharyngeal mucosa ensues. Less common are skin lesions. Cervicofacial lymph nodes become infected and appear as painless lumps that will drain over weeks or months. Treatment options include surgical excision or treatment with combination antibiotics.

The risk of iatrogenic NTM infection is reduced by following infection-prevention best practices for surgical procedures, such as sterilization guidelines and not using tap water or ice in an operating room. Previous outbreaks of *M. chimaera* associated with heater-cooler units among heart surgery patients are documented.[1,2] These infections often present years after the procedure with the epidemiological investigation unveiling the source. Other risk-reduction activities include use of adequate cleaning of baths in nail salons and using sterile water for tattoo ink.[3,4]

LEGIONELLA LURKS

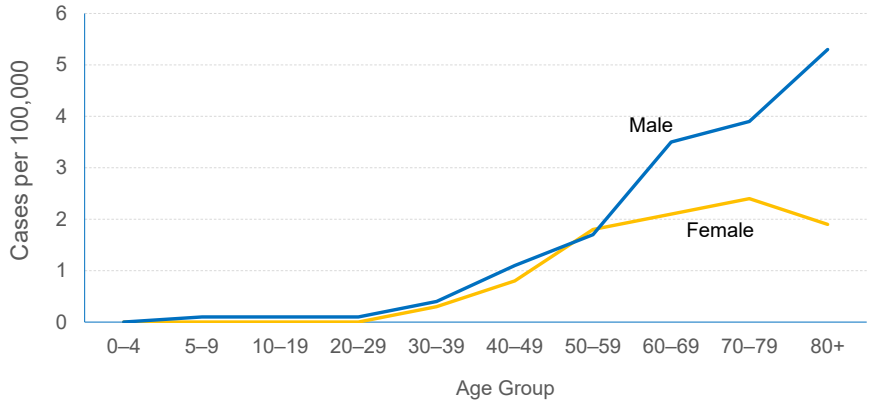
Legionella case counts and outbreaks have increased in recent years, in Oregon and nationally. Outbreaks have occurred in communities associated with large cooling towers, and in hospitals or healthcare settings, where it is believed the bacteria are protected in biofilms. Fortunately, *Legionella* is not transmitted person to person and infection, if identified early, is treatable with azithromycin. Acquisition is by inhalation of contaminated, aerosolized water. Although the causative bacterium is challenging to grow in culture, infections with *Legionella pneumophila* serogroup 1 (thought to account for ~80% of cases) can be diagnosed with a urine antigen test; however, if there is suspicion of a cluster of cases, sputum cultures with subsequent genomic sequencing can help to tie any clinical cases to an environmental source. One of the interventions developed in response to these outbreaks is the requirement to have a building water-safety management plan for hospitals and other facilities that receive Medicaid for healthcare services. Long-term care homes, colleges, and other congregate living facilities such as prisons have also adopted these practices to minimize risk to residents. *Legionella* is responsible for much of the increase in water-associated outbreaks in the U.S. Oregon reported 65 cases of legionellosis in 2020, down from a record-setting 73 cases in 2019 (Figure 3 and 4, *supra*).

WATERBORNE DISEASE BURDEN, COST AND CONTROL MEASURES

CDC recently estimated the burden of illnesses caused by 17 waterborne pathogens in the United States. Approximately 7.15 million Americans get sick every year from diseases spread through water, with an estimated cost of $3.33 billion dollars.[5]

One of the most significant public-health achievements of the 20th century is provision of reliable, disinfected drinking water. As we use water in new ways, our public health prevention strategies need to evolve. Through risk assessment, education, and environmental controls we can minimize the risk for human illness from these ubiquitous waterborne pathogens. Protocols and regulations are developed and enforced by a wide body of agencies, including the Environmental Protection Agency (EPA), the Food and Drug administration (FDA), the CDC, state and local public health agencies, and the Centers for Medicare and Medicaid Services (CMS) to name a few. Each agency plays a role in protecting people from illnesses transmitted via water. State and local public health officials investigate

Figure 3 Legionellosis incidence by age and sex; Oregon, 2011-2020

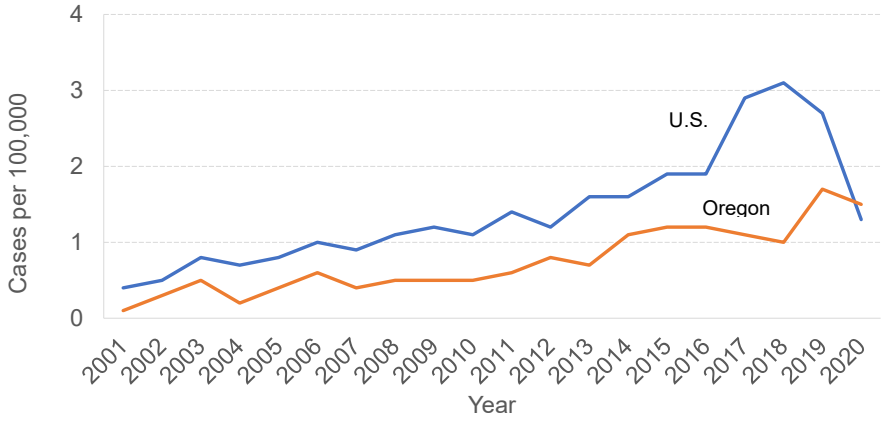


cases and outbreaks, determine exposure risk, and contribute to the epidemiological body of knowledge.

The EPA, through state and local health departments, regulates drinking water systems and develops standards and best practices. CMS requires that hospitals and healthcare systems have building water-management safety plans in place to protect vulnerable persons from *Legionella* and other opportunistic waterborne pathogens. The FDA provides recommendations and requirements for proper use, storage, and maintenance of medical equipment.

Water is ubiquitous and vital. Keeping it safe is a team sport.

Figure 4 Legionellosis US v Oregon, 2001-2020. Legionellosis became reportable in Oregon in 2001.



FOR MORE INFORMATION

- Oregon Health Authority: water-related illness www.oregon.gov/oha/PH/DISEASESCONDITIONS/COMMUNICABLEDISEASE/Pages/fs-water-related-illness.aspx
- Centers for Disease Control and Prevention: Healthy Swimming www.cdc.gov/healthywater/swimming/index.html

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