

Top 10 drinking-water and sanitation related pathogens

Key facts

- Safe drinking-water, sanitation, and hygiene (WASH) are essential for preventing infectious diseases caused by a wide range of bacteria, viruses, protozoa, and helminths.
- Most of these pathogens are enteric -affecting the gastrointestinal tract following ingestion – and cause illnesses ranging from mild diarrhea to life-threatening conditions, especially in children.
- Some enteric pathogens, particularly viruses, cause other illnesses. For example, enteroviruses cause a broad spectrum of diseases ranging from coughs, rashes and fever to aseptic meningitis, encephalitis, and poliomyelitis while hepatitis A and E viruses cause infectious hepatitis.
- There are also some important non-enteric WASH-related pathogens. This includes *Legionella pneumophila* which causes Legionnaires' disease, a serious type of pneumonia. Legionnaires' disease is most commonly contracted by inhaling contaminated aerosols from devices linked to drinking-water systems such as showers, hot tubs, and cooling systems.
- Poor water management creates habitats for disease vectors such as *Aedes* and *Anopheles* mosquitoes, which transmit dengue, Zika, chikungunya, yellow fever, and malaria. Other vector borne parasitic diseases include Guinea worm disease, schistosomiasis, or fascioliasis.
- WASH-related diseases contribute to over 1.4 million deaths annually, with diarrheal diseases being a leading cause.
- The benefits of investing in WASH are high, with every dollar invested yielding 3.9 dollars in return
- Faecal waste, from humans and/or animals are a key source of exposure of enteric pathogens. These pathogens can spread via contaminated drinking-water, recreational water, food and fomites, as well as from direct person-to-person contact.
- Over 50 pathogens are known to be transmitted through inadequate WASH, with ten pathogens contributing to the greatest burden: pathogenic *E. coli*, *Vibrio cholerae*, *Salmonella spp.*, *Shigella*, *Campylobacter*, Rotavirus, Norovirus, Hepatitis A, Adenovirus, and *Cryptosporidium*.
- Transmission of these pathogens including these ten, can be prevented through safe WASH. While vaccines are available for some such as rotavirus, *V. cholerae*, *Typhoidal salmonella* and Hepatitis A virus, they still contribute to a significant disease burden. Sustainable prevention requires long-term investments in WASH systems to address the root causes of transmission.
- Clinical care of severe diarrhoea usually comprises supportive hydration, and in some cases antimicrobial treatment, but drug resistance is a growing concern.
- Water safety plans and sanitation safety plans provide systematic approaches to proactively manage health risks associated with water and sanitation systems including from pathogens. These approaches should be included in drinking-water and sanitation regulations and audited as part of surveillance activities to ensure they are effective.
- Wastewater and environmental surveillance of key enteric pathogens can complement traditional surveillance by filling data gaps and informing public health responses.

Top 10 pathogens

The health burden of each pathogen depends on factors such as the severity and frequency of infections, the infectivity of pathogens, and the size of the exposed population.

The list of the top 10 drinking-water and sanitation-related pathogens is primarily based on pathogen-specific diarrheal disease burden data and strength of evidence on transmission through unsafe WASH. Other considerations included concerns over antimicrobial resistance for the bacteria on the list and high resistance to certain water treatment technologies (UV for adenoviruses and chlorine for *Cryptosporidium*). WHO relied on an expert panel to make judgements based on these criteria.

- ***Escherichia coli* (*E. coli*)** Some pathotypes cause severe diarrhea, mainly affecting children in low-income regions and travelers. *Enterohaemorrhagic Escherichia coli* (EHEC), includes the strain O157:H7 which can cause bloody diarrhea and hemolytic uremic syndrome (HUS), a life-threatening condition leading to kidney failure.
- ***Vibrio cholerae*** is responsible for cholera, a severe diarrheal disease leading to rapid dehydration and death if untreated. *Vibrio cholerae* serogroups O1 and O139 are responsible for millions of cases and tens of thousands of deaths annually. Cholera outbreaks have surged in recent years, driven by climate change and conflicts, with cases emerging in countries where it was previously not present.
- ***Salmonella* spp.** *Typhoidal Salmonella* cause fever, abdominal pain, and severe, life-threatening complications like intestinal perforation. It mainly affects children in endemic areas, with travel-related cases elsewhere. *Non-typhoidal salmonella* is a common cause of diarrhoea.
- ***Shigella*** is a leading cause of dysentery, causing severe diarrhea with potential complications such as hemolytic uremic syndrome (HUS). The disease disproportionately affects low-income countries, with children, the elderly, and immunocompromised individuals at higher risk.
- ***Campylobacter*** is a major zoonotic waterborne pathogen, with outbreaks occurring in small groundwater systems. It can cause severe diarrhoea. The burden of campylobacteriosis is greatest in young children in low-income countries and travel related cases elsewhere.
- ***Cryptosporidium*** is a chlorine-resistant protozoan causing watery diarrhea, often linked to contaminated drinking and recreational water. It is highly infectious and cause severe illness in immunocompromised individuals. It is one of the most important causes of diarrhoea and deaths among young children.
- **Rotavirus** is one of the leading causes of severe diarrhea in infants and young children, transmitted via contaminated water, food, and fomites but largely person-to-person contact. Rotavirus is highly infectious, requiring a low dose for transmission. Vaccination is widely promoted as a key control strategy.
- **Norovirus** is a leading cause of acute gastroenteritis worldwide. The virus is transmitted primarily via person-to-person contact and contaminated water, food and fomites are also important transmission sources. Noroviruses are infectious at very low doses, making outbreaks very common.
- **Adenoviruses** cause a significant health burden worldwide, especially in young children. While many infections are asymptomatic, they can lead to serious illnesses including gastroenteritis, respiratory infections, eye infections, and meningitis. Their high infectivity and year-round occurrence make them important public health concerns.
- **Hepatitis A virus** is highly infectious. The highest rates of acute infections and deaths occurring in low- and lower-middle-income countries although, most children are infected early, leading to high endemicity with mild disease. In high-income settings, infections in childhood are rare, making older children and adults more susceptible, and outbreaks more likely. Although mortality is rare, recovery from liver damage can take 6 weeks or longer. Most people recover with lifelong immunity. Vaccination is available for prevention.

While vaccines are available for a number of these pathogens (*rotavirus*, *V. cholerae*, *Typhoidal salmonella* and Hepatitis A virus) and provide an important tool for outbreak control and short-term protection, sustainable prevention requires long-term investment in WASH infrastructure to address the root causes of transmission. The deployment of vaccines should be strategically coordinated with WASH interventions, ensuring an integrated approach that both responds to immediate risks and supports lasting disease prevention.

Summary table

Pathogen	Evidence it is WASH preventable	Health significance	AMR concerns (WHO priority list)	Vaccine availability	Resistance to chlorine disinfection	Important animal source
<i>Escherichia coli</i> (E.coli) <i>Diarrhoeagenic and Enterohaemorrhagic</i>	Yes	High (diarrhoea, hemolytic uremic syndrome)	Yes, ESBL-producing <i>E. coli</i> is key indicator of AMR (<i>Escherichia coli</i> , carbapenem-resistant producing strains on WHO list)	No	Low	No, except for <i>Enterohaemorrhagic</i> although zoonotic transmission has been reported for other <i>Diarrhoeagenic</i> pathotypes
<i>Vibrio cholerae</i>	Yes	High (cholera)	Some resistance noted, but not on WHO priority list	Yes (oral cholera vaccine)	Low to moderate	No
<i>Salmonella spp.</i> (Typhoidal and non-typhoidal)	Yes	High (Typhoid fever, gastroenteritis)	Yes, (Fluoroquinolone-resistant <i>S. typhi</i> and Non-typhoidal <i>S. as</i> high priority on WHO list)	Yes (typhi only)	Low	<i>S. Typhi</i> : No Non-typhoidal <i>S.</i> : Yes
<i>Shigella</i>	Yes	High (dysentery)	Yes (Fluoroquinolone-resistant <i>Shigella</i> as high priority on WHO list)	No (in development)	Low	No
<i>Campylobacter</i>	Yes	High (gastroenteritis)	Some resistance noted		Low	Yes
Rotavirus	Yes	High (severe diarrhoea in children)	No	Yes	Moderate	No, zoonotic transmission may be possible
Norovirus	Yes	High (acute gastroenteritis)	No	No (in development)	Low	No, zoonotic transmission may be possible
Adenovirus	Yes (stronger evidence for transmission via unsafe sanitation)	High (often asymptomatic but can cause gastroenteritis, respiratory infections, eye infections, and meningitis)	No	No	Low	No, zoonotic transmission may be possible
Hepatitis A virus	Yes	High (acute viral hepatitis)	No	Yes	Moderate	No
<i>Cryptosporidium</i>	Yes	High (diarrhoea,)	No	No	High	Yes

Other key pathogens

While those ten pathogens are recognized as contributing most to the burden from unsafe WASH, other pathogens also present significant public health concerns. Among these are helminth parasites. Inadequate sanitation is closely linked to various helminth infections, which can result in nutritional deficiencies, anemia, and impaired cognitive development.

Water-related health risks also include numerous vector-borne diseases, such as dengue and other mosquito-borne illnesses, which are often associated with inadequate water management and storage practices.

Legionella is commonly transmitted through the inhalation of contaminated water aerosols from sources such as cooling towers and water systems. It can cause a spectrum of illness, ranging from mild, flu-like symptoms to severe and potentially fatal pneumonia (Legionnaires' disease), with complications including respiratory failure, septic shock, and multi-organ dysfunction, particularly in immunocompromised individuals. *Legionella* can be the most significant waterborne pathogen in high-income countries.

Survival in the environment

Pathogen class (bacteria, virus, protozoa, helminth) present different characteristics that influence their survival in the environment:

- Enteric bacteria can survive from weeks to month in water, soil, and faecal matter. Some pathogenic bacteria can grow in drinking-water distribution systems, particularly in biofilms. Water and wastewater treatment, including filtration and chlorination, effectively remove or inactivate most enteric bacteria.
- Viruses are much smaller and unlike bacteria, do not replicate outside a host. They can persist in water, soil, faecal matter, and fomites for extended periods. They are shed in very high numbers and are highly infectious, which makes them a major concern for waterborne disease transmission. Due to their small size, they are less effectively removed by filtration processes, and some viruses are less sensitive to disinfection (e.g., adenoviruses are among the most resistant waterborne pathogens to UV light).
- Protozoa such as *Cryptosporidium* and *Giardia* form resilient cysts or oocysts, that allows them to survive for months in water, faecal matter, and soil. Protozoa are the least sensitive to inactivation by chemical disinfection with *Cryptosporidium* cysts being highly resistant to chlorination. Filtration can effectively remove protozoa due to their larger size.
- Helminths (parasitic worms) can spread via the fecal-oral route or skin penetration by infective larvae. For some helminths, transmission involve a complex life cycle and ecological interactions. Some species, like *Ascaris lumbricoides*, release high number of eggs that are very resistant and can survive in faecal waste and soil for years under favorable conditions.

Prevention and management via drinking-water and sanitation systems

- Effective sanitation systems serve as a primary barrier against human fecal pathogens. Failures at any step of the sanitation service chain can lead to environmental contamination. Environmental pathogens can reach new hosts through contaminated drinking water, food, hands, and fomites.
- Waterborne disease outbreaks often stem from pollution of source waters including from human and animal faecal waste, inadequate water treatment, poor distribution infrastructure (e.g., cross-connections, contamination during storage), and issues such as low water pressure or intermittent supply.
- No single commonly used treatment barrier can be used alone to consistently remove all of these pathogens. *Cryptosporidium* is resistant to chlorine, while viruses may not be removed through filtration

alone. Furthermore, many waterborne outbreaks have been linked to contamination events in the distribution system. Therefore, it is essential to apply multiple barriers across the water supply chain, including protecting source waters, applying adequate water treatment and protecting drinking-water quality during distribution and storage.

- Water safety planning and sanitation safety planning are a proactive, risk-based approach to ensuring safe drinking-water and sanitation services by systematically identifying, assessing, and managing potential hazards including microbial pathogens. It is designed to protect public health by preventing contamination throughout the entire water and sanitation service chains.
- Data from the WHO/UNICEF JMP and the WHO-UN-Water GLASS initiatives indicate that while many countries are making measurable progress toward improving access to safe water and sanitation, significant disparities remain, particularly in low-income and rural areas. Strong political leadership, strengthened governance, continued investment, policy implementation, and monitoring are essential to accelerate progress and ensure equitable access for all.

WHO's response

- Compile the latest scientific evidence on [water- and sanitation- related pathogens](#)
- Promote a proactive, risk-based approach to identify and prioritize health risks from unsafe drinking-water and sanitation systems, incorporating climate resilience to its guidance - [climate resilient water safety](#) and [sanitation safely planning](#).
- Provide recommendations and guidance to support governments in developing [drinking-water](#) and [sanitation](#) regulations, as well as associated surveillance programmes.
- Monitor [WASH-related disease burden](#) and support countries with monitoring [access to water and sanitation services and systems that enable service delivery](#) (JMP and GLAAS)
- Collaborate with partners to enhance risk assessment and integrate efforts with health programmes including on [neglected tropical diseases](#) and [antimicrobial resistance](#).
- Provide guidance and build capacity for [Wastewater and environmental surveillance \(WES\)](#).
WES is disease surveillance using samples from sewage, or other environmental waters impacted by human wastewater. WES has potential to provide information alongside other forms of disease surveillance to fill gaps in other surveillance data and inform the public health response. WES has been successfully used for many years in the polio eradication programme and more recently in the COVID-19 pandemic response.