

Fighting Recreational Water Illness

A specific gang of bad actors cause RWIs. Get to know them and how to kill them

By the PHTA Recreational Water Quality Committee (RWQC)

RECREATIONAL WATER illnesses (RWIs) are a broad group of assorted infections and illnesses that result from exposure to pathogens or exposure to chemicals in aquatic venues intended for recreational use and entertainment. This article provides a general overview of only infectious RWIs associated with treated recreational water. RWIs do not include any illnesses from drinking water or water used in industrial processes (e.g., cooling and processing).

Recreational water itself is a broad category of venues that includes treated venues (e.g., swimming

RWIS: EXACTLY WHAT ARE THEY?

- Recreational Water Illnesses (RWIs) are diseases that are contracted during the use of recreational water.
- RWIs may be caused by either infection from germs in the water, illness from disinfection by-products (DBPs), or misapplication of treatment chemicals.
- The microbes that cause RWI infections include bacteria, parasites, and viruses.
- Types of RWI infections include gastrointestinal illness, dermal infections, and respiratory infections.
- All but one (*Cryptosporidium*) of the germs that cause RWIs are readily controlled by maintaining the concentration of free chlorine in pools and spas.
- Advanced treatment technology coupled with free chlorine concentration can prevent RWI infections when used with best management practices.

pools, spas, aquatic parks) as well as untreated natural waters (e.g., oceans, lakes, rivers, streams). Swimming is the fourth most popular recreational activity in the U.S. with over 301 million swims each year (U.S. Bureau of Census, 2012). Considering the popularity of swimming, the number of reported RWIs in treated venues (e.g.,

swimming pools, spas, aquatic parks) is quite low (Hlavsa, 2021).

TYPES OF MICROBES THAT CAUSE RWIS

RWIs are caused by a small number of microbes of several different types (Table 1). All of the germs that

cause RWIs are specialized in their ability to be transmitted in water. The gastrointestinal illness microbes are able to cause illness when as few as 10 cells or particles are swallowed. A typical mouthful of water swallowed by a swimmer is about 1 ounce (30 mL). If the concentration of one of these germs is 10 cells or particles for

Table 1. Microbes Known to Cause Recreational Water Illnesses

ILLNESS	TYPE OF MICROBE	POOLS	SPAS
Gastrointestinal	Bacteria	E. coli O157:H7 Shigella	None – extensive reviews of outbreak reports do not document gastrointestinal illness in spas
	Parasite	Cryptosporidium Giardia	
	Virus	Norovirus Hepatitis A	
Dermal	Bacteria	Pseudomonas aeruginosa	Pseudomonas aeruginosa
Respiratory	Bacteria	None – unless the pool has water features that generate aerosols	Legionella pneumophila

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each 1 ounce of water, the water will still be clear. So even if the water is crystal clear, there is no guarantee that water does not contain one of these germs. The list of microbes in Table 1 accounts for at least 99% of the recognized RWIs.

All of the microbes that cause gastrointestinal illness cause considerable discomfort but rarely

cause fatalities. *E. coli* O157:H7 infections in young children can cause kidney failure and lead to death if not promptly treated. All of these microbes can cause serious and persistent illness in immunocompromised individuals.

Pseudomonas aeruginosa (*P. aeruginosa*) is the only pathogen that causes dermal infections, which

includes ear infections. It is also the only pathogen that causes illnesses in both swimming pools and spas. *P. aeruginosa* was first recognized as a dermal pathogen shortly after hot tubs became popular in the early 1980s. Other species of *Pseudomonas* do exist but are not known to cause RWIs. Since *P. aeruginosa* cases are not reportable to the U.S. Centers for

Table 2. How Germs That Cause RWI Are Contracted

ILLNESS TYPE	SOURCE OF MICROBES
Gastrointestinal	Infected bathers (swimmers) shed feces in the water while swimming. These microbes do not multiply once they enter the water.
Dermal	<i>Pseudomonas aeruginosa</i> is introduced from the environment. It grows in the biofilm and is sloughed free during periods when no chlorine is present in the water.
Respiratory	<i>Legionella pneumophila</i> is introduced from the environment. It grows in the biofilm and is sloughed free during periods when no chlorine is present in the water.

Disease Control and Prevention (CDC) compared with other RWI microbes, the incidence is likely higher. Prior to the early 1980s, most of the literature considered *Staphylococcus aureus* (Staph) a cause of dermal infections from swimming pools. A complete review of the CDC's RWI outbreaks since 1978 does not show a single report of Staph infections from pools or spas (RWI Manual).

Legionella pneumophila (*L. pneumophila*) is the only recognized pathogen that causes respiratory infections. To cause a respiratory infection, cells of *L. pneumophila* must be inhaled. The operating conditions of spas provide an ideal combination of conditions for growth for this germ as *L. pneumophila* thrives in warm water. *Legionella* causes two forms of disease. Pontiac Fever is a mild illness while Legionnaires' Disease is a severe pneumonia that can be fatal in up to 40% of the cases. Because pools have cooler water and lack vigorous aerosol-producing features (e.g., misters and blowers), *L. pneumophila* RWI outbreaks do not occur in swimming pools.

METHODS OF CONTRACTING RWIS

RWI infections begin when the concentration of the germ is above some specific concentration, referred to as the minimum infective dose,

and the infective dose is introduced to the human by the correct route of exposure. For example, the infective dose of *E. coli* O157:H7 is about 10 cells; therefore, if 110 cells of *E. coli* O157:H7 are swallowed, there is a very high likelihood that the person will become ill. But if the same amount of *E. coli* O157:H7 contacts only the skin, the person will not become ill. This is because these microbes grow only in certain areas of the human body (RWI Manual).

HOW THE MICROBES THAT CAUSE RWIS ARE CONTROLLED

The primary means of controlling disease transmission in pools is free chlorine. Each type of microbe has a different physical structure that produces a unique level of resistance to the action of chlorine. This resistance to chlorine is measured by how long it takes a measured concentration of chlorine to kill, or deactivate, the cells in a measured number of minutes. The result is expressed as a "CT" value. The lower the CT value, the more easily the microbe is killed. Conversely, the higher the CT value, the more difficult it is to kill the microbe. For example, the CT value of *Giardia* (Table 3) is 45. This means that a specified number of *Giardia* cysts will be inactivated by 1 ppm of chlorine in 45 minutes.

But any combination of free chlorine concentration (C) multiplied by time (T) that equals 45 will provide the same level of inactivation. For example, if the pool was operating at 3.0 ppm of free chlorine and some *Giardia* was carried in by an infected swimmer, those *Giardia* cysts would be inactivated in 15 minutes (CPO Manual).

As seen in Table 3, all the microbes that cause RWI except for one, *Cryptosporidium*, are killed or inactivated quickly by standard concentrations of free chlorine. *Cryptosporidium* is highly resistant to free chlorine due to the physical structure of its cellular design. With its unique resistance to chlorine, any attempt to control outbreaks by this microbe using chlorine alone is not possible.

HOW OUTBREAKS OF RWI OCCUR

The CDC has been publishing surveillance summaries of RWI outbreaks since 1978. An extensive review of those surveillance summaries does not reveal a single incident of an outbreak of the chlorine-sensitive microbes when the chlorine concentration was shown to be 1.0 ppm or greater (Hlavsa, 2021; older surveillance summaries beginning at 1978 are located at www.CDC.gov/healthyswimming). A very

Table 3. CT Values of Microbes that Cause RWIs

GROUP	ORGANISM	CT VALUE FOR FREE CHLORINE	SENSITIVITY TO CHLORINE AT TYPICAL USE CONCENTRATION
Bacteria	<i>E. coli</i> (including O157:H7)	~1	Sensitive
	<i>Shigella</i>	~1	
	<i>Pseudomonas aeruginosa</i>	~1	
	<i>Legionella pneumophila</i>	~1	
Virus	Adenovirus	20 to 45	Sensitive
	Norovirus	20 to 45	
Parasites	<i>Giardia</i>	45	Resistant
	<i>Cryptosporidium</i>	15,300	

well-documented field evaluation of chlorine effectiveness calculated that if the free chlorine concentration was 1.0 ppm or greater, there was a 99% chance that RWI outbreaks would be prevented (Esterman, 1984). A review of aquatic venue inspections has shown that facilities are failing to maintain adequate chlorination levels between 10 and 14% of the time (Hlavsa, 2013). RWIs due to chlorine-sensitive microbes would be prevented if the free chlorine level is maintained at 1.0 ppm or greater.

The exception to this is *Cryptosporidium*. *Cryptosporidium* is so resistant to chlorine that if the pool were operating at 10 ppm free chlorine and a *Cryptosporidium* fecal accident occurred, it would take at least 1,530 minutes, or 25.5 hours, to inactivate enough of the oocysts for the water to be considered safe for swimming. As a comparison, under the exact 10 ppm of free chlorine with a *Giardia* fecal accident the water would be considered safe after just 4.5 minutes. Outbreaks of *Cryptosporidium* continue for several days after the initial fecal accident until the concentration of infective oocysts slowly declines. If infected swimmers continue to use the facility, the outbreak can last for several weeks or months. To limit outbreaks of *Cryptosporidium*, advanced treatment systems, such as Secondary Disinfection Systems using UV or ozone as specified in ANSI/APSP/ICC-11 American National Standard for Water Quality in Public Pools and Spas (2019) and the Model Aquatic Health Code (MAHC, 2018), must be utilized.

TREATMENT METHODS TO PREVENT RWI OUTBREAKS

- Employ trained lead operators
- Have adequately trained staff available during all hours of operation
- Instruct and enable 2nd and/or 3rd shift personnel to close the venue without the need to consult with the primary operator if the free chlorine concentration is below the minimum or there is a vomit or fecal accident
- Maintain at least 1.0 ppm of free

chlorine at all times

- Test the water at appropriate intervals to ensure that the free chlorine concentration never falls below 1.0 ppm free chlorine during periods of high bather use
- Close the facility and evacuate all swimmers from the water IMMEDIATELY if:
 - The free chlorine drops below 1.0 ppm of free chlorine
 - The circulation system is not functioning properly
 - The chlorine feeder system is not functioning properly
 - There is any vomit in the water
 - There is a formed fecal accident
 - There is a diarrheal accident

Do not reopen the facility until the situation is properly resolved.

- In “increased risk aquatic venues” utilize properly sized Secondary Disinfection Systems as detailed in ANSI/APSP/ICC-11 (2019) and the MAHC (2018). An “increased risk aquatic venue” is an aquatic venue which has an increased risk of microbial contamination due to its primary users being children under the age of five and/or people more susceptible to infection, such as therapy patients with open wounds. Examples of increased risk aquatic venues include spray pads, wading pools, therapy pools, and other aquatic venues designed for children under the age of five (refer to ANSI/APSP/ICC-11, 2019).
- Consider using properly sized Supplemental and Secondary Disinfection Systems in all public swimming venues as appropriate, following manufacturer’s use instructions.

Methods to treat outbreaks must be tailored to the type of microbe involved. Additional information on remedial treatments is available from PHTA at www.PHTA.org. ~

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ADDITIONAL INFORMATION FROM THE PHTA

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2. “*E. coli* O157:H7” Fact Sheet, Pool and Hot Tub Alliance, 2017.
3. “Legionellosis” Fact Sheet, Pool and Hot Tub Alliance, 2017.
4. “Secondary vs. Supplemental Disinfection Systems” Fact Sheet, Pool and Hot Tub Alliance, 2020.

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