The following information resources have been selected by the National Health Library and Knowledge Service Evidence Virtual Team in response to your question. The resources are listed in our estimated order of relevance to practicing healthcare professionals confronted with this scenario in an Irish context. In respect of the evolving global situation and rapidly changing evidence base, it is advised to use hyperlinked sources in this document to ensure that the information you are disseminating to the public or applying in clinical practice is the most current, valid and accurate. . For further information on the methodology used in the compilation of this document—including a complete list of sources consulted—please see our National Health Library and Knowledge Service Summary of Evidence Protocol.

YOUR QUESTION

What is known about the survival of SARS-CoV-2 in open water—sea and fresh water; waste water and sewage. What are the implications to human health of recreational activities in open water such as kayaking or swimming?

IN A NUTSHELL

The World Health Organization[1] reports that while there is no evidence about the ability of the SARS-CoV-2 virus to survive in sewage enveloped viruses such as COVID-19 tend to become inactivated with waterborne transmission. WHO also found no evidence that the SARS-CoV-2 virus has been transmitted via sewerage systems with or without wastewater treatment and stated that conventional water treatment methods that use filtration and disinfection should inactivate the SARS-CoV-2 virus.

The Centers for Disease Control and Prevention in the Unites States[2] state that scientists cannot specify the risk that the virus could be spread from the feces of an infected person to another person. However, they estimate that the risk is low based on data from previous outbreaks of diseases caused by related coronaviruses such as SARS and MERS. Similarly, the virus that causes COVID-19 has been found in untreated wastewater. Researchers do not know whether the virus can cause the disease if a person is exposed to untreated wastewater or sewerage systems. The CDC found no evidence showing infection with COVID-19 through drinking water, recreational water or wastewater and estimated the risk of such trasmission to be low.

Although studies on survival of the SARS-CoV-2 virus in open waters are not yet available, there have been some studies on previous coronaviruses suggesting that contaminated water is a potential vehicle for human

exposure[3,5,6]. The evidence is equivocal, however, with another study finding that coronaviruses die off rapidly in wastewater[4]. Some experts have postulated that when the SARS-CoV-2 virus gets into large bodies of water such as rivers and oceans, the concentration of the virus would be so diluted that it would be difficult to contract[8]. Although studies are not available on the ability of the virus to remain viable in seawater, the main risk of contracting COVID-19 during recreation may come from person-to-person transmission and failing to maintain sufficient social distancing rather than direct infection via open water [8,9].

IRISH AND INTERNATIONAL GUIDANCE

What does the World Health Organization say?

World Health Organization (2020) Water, sanitation, hygiene, and waste management for the COVID-19 virus[1]

Currently, there is no evidence about the survival of the COVID-19 virus in drinking-water or sewage. The morphology and chemical structure of the COVID-19 virus are similar to those of other human coronaviruses for which there are data about both survival in the environment and effective inactivation measures.

Although persistence in drinking water is possible, there is no evidence from surrogate human coronaviruses that they are present in surface or groundwater sources or transmitted through contaminated drinking water.

The COVID-19 virus is an enveloped virus, with a fragile outer membrane. Generally, enveloped viruses are less stable in the environment and are more susceptible to oxidants such as chlorine. While there is no evidence to date about survival of the COVID-19 virus in water or sewage, the virus is likely to become inactivated significantly faster than non-enveloped human enteric viruses with known waterborne transmission such as adenoviruses, norovirus, rotavirus and hepatitis A.

Conventional, centralized water treatment methods that use filtration and disinfection should inactivate the COVID-19 virus. Other human coronaviruses have been shown to be sensitive to chlorination and

disinfection with ultraviolet light. There is no evidence that the COVID-19 virus has been transmitted via sewerage systems with or without wastewater treatment. As part of an integrated public health policy, wastewater carried in sewerage systems should be treated in well-designed and well-managed centralized wastewater treatment works.

What do the Centers for Disease Control and Prevention (United States) say?

Centers for Disease Control and Prevention (2020). Water and COVID-19 FAQs: Information about Drinking Water, Recreational Water and Wastewater[2]

The virus that causes COVID-19 has been found in the feces of some patients diagnosed with COVID-19. However, it is unclear whether the virus found in feces may be capable of causing COVID-19. There has not been any confirmed report of the virus spreading from feces to a person. Scientists also do not know how much risk there is that the virus could be spread from the feces of an infected person to another person. However, they estimate that the risk is low based on data from previous outbreaks of diseases caused by related coronaviruses such as severe acute respiratory syndrome and Middle East respiratory syndrome.

The virus that causes COVID-19 has been found in untreated wastewater. Researchers do not know whether this virus can cause disease if a person is exposed to untreated wastewater or sewerage systems. There is no evidence to date that this has occurred. At this time, the risk of transmission of the virus that causes COVID-19 through properly designed and maintained sewerage systems is thought to be low. Researchers have analyzed the available information which suggest that standard municipal and individual septic system wastewater treatment practices should inactivate the virus that causes COVID-19.

There is no evidence showing anyone has been infected with COVID-19 through drinking water, recreational water or wastewater. The risk of COVID-19 transmission through water is expected to be low.

INTERNATIONAL LITERATURE

What does the international literature say?

Casanova et al (2009) Survival of surrogate coronaviruses in water[3]
The emergence of a previously unknown coronavirus infection—severe acute respiratory syndrome (SARS)—demonstrated that fecally contaminated liquid droplets are a potential vehicle for the spread of a respiratory virus to large numbers of people. To assess potential risks from this pathway, there is a need for surrogates for SARS coronavirus to provide representative data on viral survival in contaminated water. This study evaluated survival of two surrogate coronaviruses, transmissible gastroenteritis (TGEV) and mouse hepatitis (MHV). These viruses remained infectious in water and sewage for days to weeks. At 25 °C, time required for 99% reduction in reagent-grade water was 22 days for TGEV and 17 days for MHV. In pasteurized settled sewage, times for 99% reduction were 9 days for TGEV and 7 days for MHV. At 4 °C, there was <1 log10 infectivity decrease for both viruses after four weeks. Coronaviruses can remain infectious for long periods in water and pasteurized settled sewage, suggesting contaminated water is a potential vehicle for human exposure if aerosols are generated.

Gundy et al (2009) Survival of Coronaviruses in Water and Wastewater[4]
The advent of severe acute respiratory syndrome and its potential environmental transmission indicates the need for more information on the survival of coronavirus in water and wastewater. The survival of representative coronaviruses, feline infectious peritonitis virus and human coronavirus 229E was determined in filtered and unfiltered tap water [4°C and 23°C] and wastewater [23°C]. This was compared to poliovirus 1 under the same test conditions. Inactivation of coronaviruses in the test water was highly dependent on temperature, level of organic matter, and presence of antagonistic bacteria. The time required for the virus titer to decrease 99.9% [T99.9] shows that in tap water, coronaviruses are inactivated faster in water at 23°C [10 days] than in water at 4°C [>100 days]. Coronaviruses die off rapidly in wastewater, with T99.9 values of between 2 and 4 days. Poliovirus survived longer than coronaviruses in all test waters, except the 4°C tap water.

Wang et al (2005) Concentration and detection of SARS coronavirus in sewage from Xiao Tang Shan hospital and the 309th Hospital of the Chinese People's Liberation Army[5]

The transmission of severe acute respiratory syndrome-associated coronavirus (SARS-CoV) is associated with close contact to SARS patients and droplet secretions of those patients. The finding of positive RT-PCR results from stools of SARS patients suggests that stools of SARS patients or sewage containing stools of patients could transmit SARS-CoV. We used a novel style of electropositive filter media particle to concentrate the SARS-CoV from the sewage of two hospitals receiving SARS patients in Beijing. We also used cell culture, RT-PCR and gene sequencing to detect and identify the viruses from sewage. No infectious SARS-CoV contamination was found in any of the samples collected, but the nucleic acid of SARS-CoV could be detected in the sewage from the two hospitals before disinfection. While the RNA was only detected in three samples from the hospital, the others were negative after disinfection. These findings provide strong evidence that SARS-CoV can be excreted through the stool/urine of patients into sewage system, thus making the sewage system a possible route of transmission.

Sobsey et al (2020) Virus survival in the environment with special attention to survival in sewage droplets and other environmental media of fecal or respiratory origin[6]

The extent to which viral pathogens of humans and animals persist in the environment to reach other hosts is of considerable public health interest and concern. Viruses can be transmitted by a variety of routes, including direct and indirect contact, vector transmission and vehicle transmission. For many human and animal viruses, vehicle transmission includes respiratory transmission by droplets and aerosols and fecal-oral transmission via water, food and fomites such as environmental surfaces. Consequently, for viruses transmitted by the respiratory and fecal-oral routes, transport and persistence in environment is directly related to the potential for and risk of transmission, host exposure, infection and disease. Viral persistence, survival and transport can vary greatly with virus type and environmental conditions. This review will summarize the factors influencing virus persistence, survival and transport in the environment, especially for viruses transmitted by the fecal-oral and respiratory routes and with special consideration of the SARS virus and other coronaviruses. Data will be presented for environmental persistence of a range of virus types in different environmental media and matrices, including air, water, waste and

surfaces and under different environmental conditions influencing virus survival, persistence and transport.

Griffin et al (2003) Pathogenic Human Viruses in Coastal Waters[7]

This review addresses both historical and recent investigations into viral contamination of marine waters. With the relatively recent emergence of molecular biology-based assays, a number of investigations have shown that pathogenic viruses are prevalent in marine waters being impacted by sewage. Research has shown that this group of fecal-oral viral pathogens — enteroviruses, hepatitis A viruses, Norwalk viruses, reoviruses, adenoviruses, rotaviruses, etc. — can cause a broad range of asymptomatic to severe gastrointestinal, respiratory and eye, nose, ear and skin infections in people exposed through recreational use of the water. The viruses and the nucleic acid signature survive for an extended period in the marine environment. One of the primary concerns of public health officials is the relationship between the presence of pathogens and the recreational risk to human health in polluted marine environments. While a number of studies have attempted to address this issue, the relationship is still poorly understood. A contributing factor to our lack of progress in the field has been the lack of sensitive methods to detect the broad range of both bacterial and viral pathogens. The application of new and advanced molecular methods will continue to contribute to our current state of knowledge in this emerging and important field.

OTHER

Anoruo (2020) [News Article] What experts say about coronavirus in water and what it means for beach season[8]

Although infectious droplets may contaminate water and the virus has been detected in wastewater, experts agree that when it gets into large bodies of water such as lakes, rivers and oceans the concentration of the virus would be so diluted that it would be difficult to contract it.

According to the Centers for Disease Control and Prevention, there's no evidence that people can become infected through recreational swimming, and "the risk of COVID-19 transmission through water is expected to be low." While experts agree it's unlikely you will get infected with COVID-19 by recreational water activities, they did have another concern about resuming water activities: loosening social-distancing. Dr. Benjamin Gewurz, Infectious

Disease Physician and Associate Chair of the Harvard Graduate Program in Virology, emphasized that the primary mode of COVID-19 infection is still person-to-person transmission, and the primary reason to avoid a fun weekend by the water would be to maintain a safe distance from others who could be infected. This is particularly important since people can have COVID-19 and not show any symptoms.

Day (2020) [Blog] COVID-19 and Beach Water Quality: Updates from the Research Community[9]

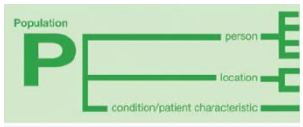
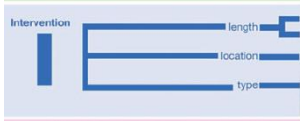
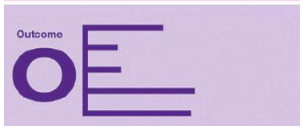
The Water Research Foundation hosted a webinar on March 12 to look at how the virus survives in water. Surfrider Foundation reported some of the key results. The virus has been shown to remain viable and infectious, at least temporarily, in natural freshwater environments including lakes and streams. While dilution is suspected to keep the risk low, high concentrations of the viable COVID-19 virus could put freshwater recreation users at risk. There is still no information on the ability of the COVID-19 virus to remain viable in saltwater, so it's unclear if swimming at saltwater beaches elevates the risk of contracting COVID-19. However, communal spread is a serious issue so spending time at popular beaches, if in close contact with other beachgoers, will increase your risk.

Similar to many harmful viruses and pathogens, the main exposure risk to the water recreation community is from sewage pollution. The release of raw or undertreated sewage into our surface waterways can cause diseases to spread through the fecal-oral transmission route. At this point, the research community does not know if people can contract the COVID-19 virus from exposure to feces in recreational waters but the overall consensus is that it might be possible. The RNA of the virus was found in stool samples of infected patients, but we do not know if the virus remains infectious after passing through the human digestive system.

A proposed study to determine if the infectious COVID-19 virus is present in sewage-polluted coastal water and able to aerosolize in sea spray, submitted by Dr. Kim Prather from Scripps Institution of Oceanography, was recently awarded funding by the National Science Foundation, with plans to start immediately. In the meantime, researchers from a recent Water Research Foundation webinar stated that the likelihood of catching COVID-19 from feces seems low since other coronaviruses are susceptible to UV radiation and unable to persist over long periods of time in waterways, but again this is all preliminary and not yet confirmed.

Produced by the members of the National Health Library and Knowledge Service Evidence Team†. Current as at 30 April 2020.This evidence summary collates the best available evidence at the time of writing and **does not replace clinical judgement or guidance**. Emerging literature or subsequent developments in respect of COVID-19 may require amendment to the information or sources listed in the document. Although all reasonable care has been taken in the compilation of content, the National Health Library and Knowledge Service Evidence Team makes no representations or warranties expressed or implied as to the accuracy or suitability of the information or sources listed in the document. This evidence summary is the property of the National Health Library and Knowledge Service and subsequent re-use or distribution in whole or in part should include acknowledgement of the service.

The following PICO(T) was used as a basis for the evidence summary:

	GENERAL POPULATION ENGAGING IN OPEN WATER SPORT/ACTIVITY
	TREATED WATER
	
	

The following search strategy was used:

"covid-19" OR coronavirus OR "wuhan virus" OR "2019-ncov" OR "severe acute respiratory syndrome coronavirus 2" OR "2019 novel coronavirus" OR "2019 new coronavirus" OR MERS OR Middle East Respiratory Syndrome OR SARS or Severe Acute Respiratory Syndrome

AND sea water OR salt water OR seawater OR saltwater OR open water* OR sewage OR sewerage OR bathing OR swimming OR kayaking OR canoeing OR water sport*

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[1] World Health Organization (2020) Water, sanitation, hygiene, and waste management for the COVID-19 virus. https://www.who.int/publications-detail/water-sanitation-hygiene-and-waste-management-for-covid-19.

[2] Centers for Disease Control and Prevention (2020). Water and COVID-19 FAQs : Information about Drinking Water, Recreational Water and Wastewater. https://www.cdc.gov/coronavirus/2019-ncov/php/water.html.

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