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► To cite this version:

S. Romano-Bertrand, L-S. Aho Glele, B. Grandbastien, D. Lepelletier. Preventing SARS-CoV-2 transmission in rehabilitation pools and therapeutic water environments. *Journal of Hospital Infection*, 2020, 105 (4), pp.625-627. 10.1016/j.jhin.2020.06.003 . hal-03031457

HAL Id: hal-03031457

<https://hal.umontpellier.fr/hal-03031457>

Submitted on 18 Jul 2022

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Title: Preventing SARS-CoV-2 transmission in rehabilitation pools and therapeutic water environments

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Words count: 1202

Summary

SARS-CoV-2 is mainly transmitted by respiratory droplets and contact with contaminated surfaces. It can be retrieved in faeces but there is no evidence of faecal-oral transmission, which is the main route of contamination in recreational waters. Standard cleaning and disinfecting procedure, microbiologic control and health rules aim to prevent infectious risk regardless of the microorganisms. In the context of progressive lockdown exit and hospital activities recovery, we assessed the risk of SARS-CoV-2 transmission in rehabilitation pools and therapeutic water environments in order to provide specific recommendations to control the spread of SARS-CoV-2 while ensuring essential rehabilitation cares for patients.

Key-words: coronavirus; COVID-19; waterborne infection; oral-faecal transmission; viral pandemic

SARS-CoV-2 is mostly transmitted by droplets and contact with contaminated surfaces but can also be retrieved in high load in feces [1]. It is mainly responsible of both respiratory and gastrointestinal symptoms but there is no evidence of SARS-CoV-2 faecal-oral transmission to date [2]. A recent research letter suggested a possible cross-transmission of SARS-CoV-2 between 9 patients via bathing in a public bath centre [3], underlining the need to implement specific measures to prevent this risk. In the context of progressive hospital activities recovery, we assessed the risk of SARS-CoV-2 transmission in rehabilitation pools and therapeutic water environments in order to protect patients and healthcare workers from COVID-19. To do so, we reviewed the current literature on SARS-CoV-2 sustainability in water environments. We also made an overview on risk and likely causes of viral cross-transmission in swimming pools. The different methods for swimming pool water disinfection in order to maintain its microbiological quality were described. According to this risk assessment strategy, we proposed pragmatic recommendations to control the risk of SARS-CoV-2 cross-transmission while preserving essential rehabilitation cares for patients.

SARS-CoV-2 sustainability in water environments

SARS-CoV-2 environmental sustainability is conditioned by the initial viral load, the type of support, the residual humidity, the temperature and the presence of biologic fluids. SARS-CoV-2 survival conditions in biologic fluids are not transposable to recreational water and there are no current data on SARS-CoV-2 stability in water environments such as swimming pools. However, coronaviruses seem instable in water environment and are very sensitive to chlorine [4]. Enveloped virus including influenza viruses and coronaviruses, are too sensitive in environment and too rapidly inactivated in water to be transmitted within swimming pools; this is converse to naked viruses such as adenoviruses, noroviruses, enteroviruses or hepatitis A virus, that are usually more resistant and able to survive several days in water, even when

treated by biocides such as chlorine, ozone or bromide [4,5]. Accordingly, water from swimming pools does not appear favourable for survival of SARS-CoV-2.

Swimming pools and risk assessment of viral cross-transmission

Most outbreaks related to contaminated recreational waters are caused by oral-faecal transmission of enteric viruses [6,7]. Investigating water-borne viral outbreaks is hampered by the requirement to sample very large volumes of water (1,000 to 2,000 L), which helps explain why the causative virus is identified in water in less than 28% of cases.

Viruses can contaminate swimming pools for various reasons including inadequate compliance with disinfection procedures due to technical failures or human factors (lack of, or incompetent, maintenance); lack of a warning system; or faecal soiling by infected users. Although few specific data are available, the same risks apply to rehabilitation pools and therapeutic water environments.

Viruses are not able to replicate on inanimate supports out of host tissues and cells.

Consequently, the presence of viruses in water of swimming pools is directly linked with contamination by bathers that excreted biologic fluids such as saliva, mucus, vomit or faeces (<http://www.who.int/iris/handle/10665/43336>). Ingestion by the oral route remains the most frequent route of viral transmission in water, but the ocular mucosa may also be an important a portal of entry for SARS-CoV-2 [8,9], possibly contributed to by irritation caused by chemical products used for disinfecting water. Skin lesions (injury, barrier disruption) may also allow viral entry, possibly contributed to by the skin softening that occurs with prolonged immersion in water; however, this mode of transmission has not been demonstrated for SARS-CoV-2.

Standards of cleaning and disinfection procedure in swimming pools

Strict standards apply for treating water and maintaining its quality in swimming pools. In both public and hospital swimming pools, the water must be filtered and disinfected, and must meet physical, chemical and microbiological qualities defined by the French Public Health Code [10]. The Code also defines the required frequencies of monitoring of physicochemical and microbiological indicators, and the processes for pool closure and maintenance operations in case of non-conformity.

Disinfectant added to water must kill or inactivate microorganisms while preserving skin, eyes and mucosa integrity. Chlorine is usually used because of its cost-effectiveness, easy use and safety (<https://www.cdc.gov/coronavirus/2019-ncov/php/water.html>). Measures of cleaning and disinfecting must be accompanied by strict hygiene and behavioral rules for bathers, along with the respect of capacity limit of bathers, which cannot be higher than 3 per 2m³ of water in open-air recreational waters, and 3 per m³ in covered swimming pools [10].

Specific preventive measures regarding SARS-CoV-2 transmission

The first line of prevention of SARS-CoV-2 transmission is based on barrier measures including hand hygiene, physical distancing, and respiratory hygiene (wearing of a mask, covering the mouth and nose appropriately when coughing or sneezing). However, these precautions are difficult or impossible to apply by patients when bathing. We propose here a range of specific measures for pools used for rehabilitation care to protect bathers and healthcare workers from SARS-CoV-2 (Table I). Ensuring safety begins with reviewing clinical records to ensure that patients have no symptoms of COVID-19, followed by use of barrier precautions and social distancing, especially in dressing rooms. Indeed, the main risk of SARS-CoV-2 cross-transmission is through respiratory droplets and contact with contaminated surfaces, and strict application of barrier measures is the best way to prevent transmission. Hand hygiene measures include appropriate provision of hydro-alcoholic

solution for use on dry hands, but also soap and water for washing wet hands.

All these recommendations are based on the guidelines issued by the French Society for Hospital Hygiene (<https://www.sf2h.net/wp-content/uploads/2020/03/Avis-SARS-CoV-2-et-eau-de-piscine-SF2H-09.03.2020.pdf>) and are applicable to therapeutic pools and other therapeutic water environments. Meeting usual pool disinfection standards, together with appropriate individual behaviours in the pool should be sufficient to prevent a risk of waterborne transmission of SARS-CoV-2 (<https://www.wef.org/news-hub/wef-news/the-water-professionals-guide-to-the-2019-novel-coronavirus/>). These precautions must be accompanied by strict respect of barrier measures by both patients and healthcare workers outside of the pool. All these measures may also be applicable to public and private swimming pools in order to control the transmission of SARS-CoV-2 in the community.

Financial support: none to declare

Conflict of interest: none to declare

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Table I: Prevention measures of SARS-CoV-2 transmission in rehabilitation pools and therapeutic water environments

Specific recommendations	
For technical staff	<p>Ensure the proper application of standard guidance from the French Public Health Code in order to prevent from microbiologic risks in pools</p> <ul style="list-style-type: none"> • appropriate procedure of water disinfection using chlorine or other disinfecting product • monitoring physicochemical indicators • monthly microbiologic control of water • pool closing and maintenance operation in case of non-conformity • frequent surfaces disinfection with appropriate product [#]
For patients	<p>Ensure the respect of hygiene and behavioral rules before entrance in pools</p> <ul style="list-style-type: none"> • use individual dressing rooms • clothes storage on hangers in individual dedicate compartments • shower using soap and water (before and after bathing) • booth bath • wearing of swim cap • wearing of swimming goggles
	<p>Avoid access to bathers suspect or affected of COVID-19 *</p> <p>Avoid or restrict access to bathers presenting respiratory and/or digestive symptoms *</p>
	<p>Ensure that bathers respect strictly barrier measures in order to prevent cross-transmission outside of pools</p> <ul style="list-style-type: none"> • strict hand hygiene at the entrance in the building and in case of bathroom use • surgical mask wearing until reaching the dressing room and once dressed after bathing • physical distancing of at least one metre • sneeze and cough into hands then directly wash their hands with soap and water [°] • avoid touching face, nose, mouth and eyes
For healthcare workers	<p>Ensure the strict respect of barrier measures in order to prevent cross-transmission outside of pools</p> <ul style="list-style-type: none"> • surgical mask wearing • physical distancing of at least one metre • regular hand hygiene • avoid touching face and eyes • wearing of goggles or face shield in case of close contact with patient

[#] Disinfection of common surfaces at both opening and closure of pools, and disinfection of dressing rooms and high touch surfaces between patients. Recommended disinfectants are 0.5% bleach, 70° alcohol or usual disinfectant with virucidal activity according to the norm EN14464+A2 (July 2019).

* by reviewing clinical record of patients.

[°] because it appears impossible to cough and sneeze in elbow when bathing, we recommend to use hands then immediately perform hand hygiene by washing hands with soap and water for at least 30 seconds as the use of hydro-alcoholic solution is not recommended on wet hands.