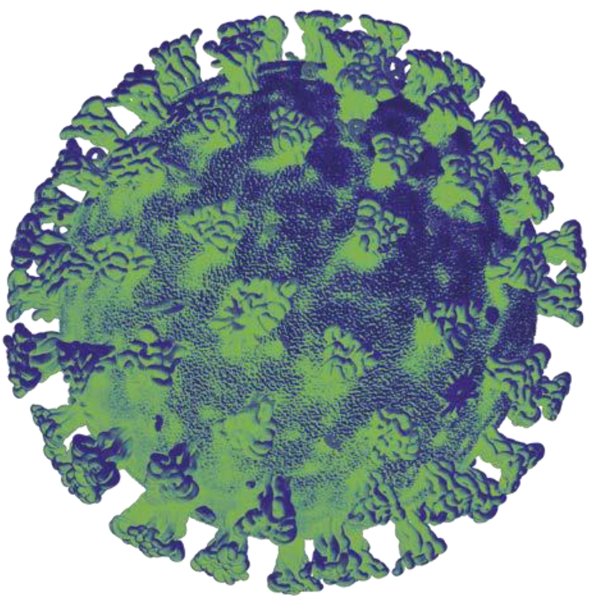
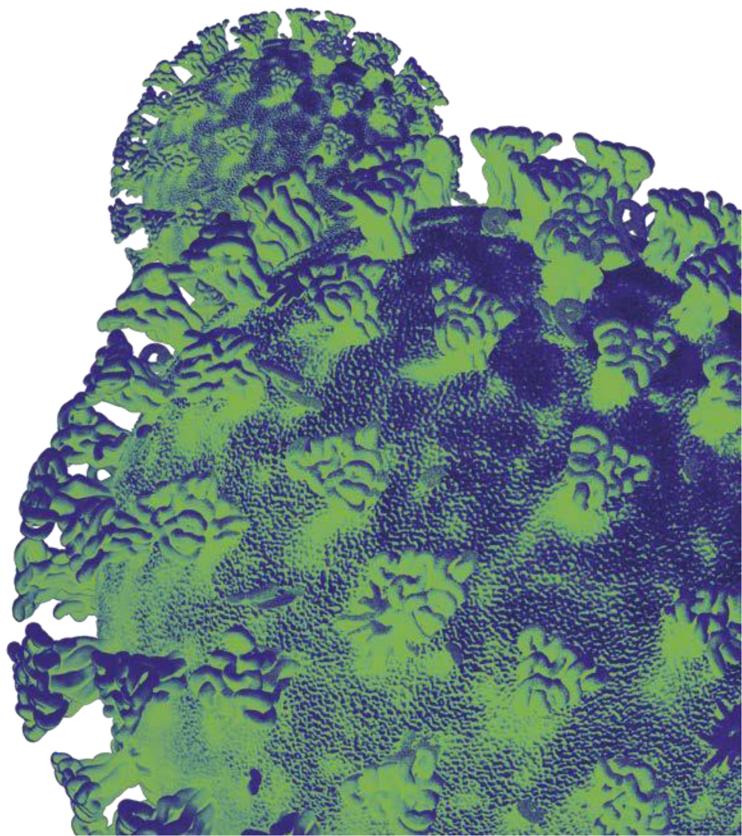
Llywodraeth Cymru
Welsh Government

Technical Advisory Group

Swimming Pools, Hot Tubs, Saunas and Steam Rooms and Risk from Covid-19

04 November 2020





Technical Advisory Group Environmental Sub Group

Swimming Pools, Hot Tubs, Saunas and Steam Rooms and Risk from Covid-19

This document identifies the risks associated with the use of swimming pools, saunas, steam rooms, and hot tubs within the context of COVID-19 before outlining mitigations. This paper relates to communal / commercial facilities rather than domestic, although some common principles apply such as 'you can't 'sweat' the virus out'. **The current, national and local guidance about restrictions (i.e. household bubbles, social distancing etc.) should always apply**.

The most important thing to avoid spreading the infection is not to visit these facilities if individuals are exhibiting symptoms of COVID-19. Some of the facilities considered here operate at high temperature; it is important to emphasise that viral release in sneezing or coughing can reach another person without the virus having time to be killed, regardless of temperature.

Hot Tubs and Swimming Pools

There has already been technical guidance set out by the Pool Water Treatment Advisory Group for Swimming Pools and Hot tubs (Links Below). However, **it is still important to emphasise social distancing, surface cleaning, hand washing, and household bubbles with this guidance**.

For swimming pools and hot tubs, guidance is available from the Pool Water Treatment Advisory Group, see: https://www.pwtag.org/technical-notes/, and in particular:

Disinfecting coronavirus (Technical Note 44 – version 3 updated October 2020)
Reopening a pool after Covid-19 shutdown (Technical Note 45)
Swimming pool technical operation after Covid-19 shutdown (Technical Note 46)
TN46 supplementary note: Covid-Safe Pool Operation – An Update (Technical Note 46-B)
Spa and hot tub technical operation after Covid-19 shutdown (Technical Note 47)
Paddling pool and splash park management during the Covid-19 pandemic (Technical Note 51)

Current evidence base: There is very little published guidance or peer-reviewed primary research pertaining to the potential persistence and risk of transmission of SARS-CoV-2 in saunas, steam rooms and related facilities. To date, no cases of COVID-19 have been directly linked to the use of these facilities in the UK, however, the difficulties in tracing the source of infections is widely acknowledged. Some cases of COVID-19 transmission between unrelated individuals in similar facilities have been documented in China (Luo et al., 2019). Consequently, no evidence of transmission in these environments cannot be equated to no risk. Consequently, this paper critically reviews the available evidence and provides expert judgement on the likely risk of person-to-person transmission of SARS-CoV-2 in these environments.

Definition of sauna and steam room facilities: For Saunas and Steam Rooms, the following definitions have been used:

- A **sauna** is a wooden construction where the internal air is dry, operating at temperatures above 70°C with humidity as low as 3%, but usually between 5 and 20%. In the UK most saunas are "Finnish saunas" which operate around 70-90°C with higher end humidity.
- A **steam room** operates at high humidity of around 90 to 100% and at temperatures typically up to around 45°C. Steam is often blown into the room. The finished surfaces are usually tiled.
- In addition, there are variants such as steam showers, saunariums, infrared saunas etc.
- In some models of both saunas and steam rooms, it may be difficult to keep the temperature and humidity constant, for example due to manual controls, lack of trained operators or reliance on users.

Key factors to be considered:

The survival and transmission of viruses (and other microorganisms) is dependent on a combination of factors. In the context of saunas and steam rooms there are a number of key factors identified:

(i) Temperature and humidity,
(ii) Exposure times,
(iii) Surfaces present inside the room (e.g. benches, door handles, controls),
(iv) Physical dimensions of the facility (i.e. capacity to social distance),
(v) Lack of ventilation,
(vi) Internal furniture and other equipment (e.g. steam blowers etc.),
(vii) Behaviour of individuals in these facilities, and
(viii) Associated activities that occur external to the sauna and steam room (e.g. changing rooms, showers, and plunge pools).

However, the most critical factor is the potential for person-to-person spread in these confined spaces.

Thermal inactivation of SARS-CoV-2: Heat inactivates the virus by denaturing the structure of the proteins, affecting the attachment and replication of the virus in the host cell. There is strong evidence to show that elevated temperatures inactivate the virus. Although a recent PHE report demonstrated a lack of / variable heat inactivation of the virus in media containing fetal calf serum, there is published evidence for thermal inactivation in relevant samples (e.g. spiked nasopharyngeal fluids). Using a combination of restricted use, appropriate cleaning and fallow periods the transmission risk in the facilities considered here should be reduced.

However, whilst the research literature generally supports this principle, there are subtle differences between the agreed temperature and timings found in these independent studies.

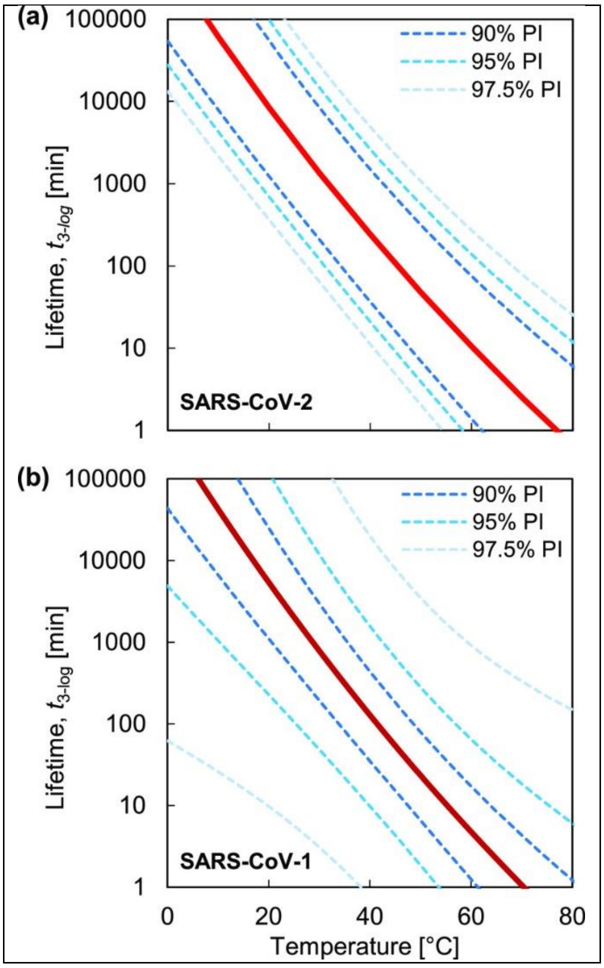
It is clear from the literature that SARS-CoV-2 is relatively stable at room temperature (20-30°C) but becomes susceptible to inactivation at higher temperatures (>50°C; Wang et al., 2020) within differing time periods. Further, this inactivation is facilitated by longer exposure times and in the presence of chemical disinfectants. One study showed that heating SARS-CoV-2-spiked nasopharyngeal fluids to 56°C for >30 min completely eliminated the presence of infectious virus (Pastorino et al., 2020). The same study showed that heating at 92°C for 15 min also completely eliminated the virus.

The efficacy of the 56°C for 30 min and 60°C for 60 min treatments (virus in water) were in line with results observed using canine coronavirus and mouse hepatitis coronavirus (3.88 to 4.51 $\log_{10}$ reduction factor) heated to 60°C for 30 min (Saknimit et al., 1988) and other enveloped viruses (Watanabe et al., 1989). When the incubation temperature was increased to 70°C, the time for virus inactivation was reduced to 5 mins (Chin et al., 2020). A study by Patterson et al. (2020) also showed complete inactivation of SARS-CoV-2 by heating the virus to 80°C for 1 hour.
In a critical review of the literature Abrahams et al. (2020) reported that at temperatures above 65°C, near-complete inactivation should occur after exposure for 3 minutes. For temperatures between 55 and 60°C heating should last 5 min to eliminate the virus, while for temperatures in the range 50-55°C, they recommend heating for 20 min or longer. Using these thermal regimes, they expect the viral concentration to be lowered by Log_{10} 5-7, to near or below the detectable limit. The comprehensive review goes further and presents a set of recommendations for effective thermal inactivation. This was based on evidence of the impact of thermal stress on coronaviruses in general. After building in a safety factor, the following recommendations for the thermal inactivation of SARS-CoV-2 were proposed (Abraham et al., 2020):

- 3 minutes at temperature above 75°C
- 5 minutes for temperatures above 65°C
- 20 minutes for temperatures above 60°C

The thermodynamic modelling study of Yap et al. (2020) also came to a similar conclusion to Abrahams et al. (2020). A summary of their findings is shown below (Fig. 1).

Fig. 1. Lifetimes of SARS-CoV-2 (a) and SARS-CoV-1 (b) in response to temperature. The lifetime represents a 3 $\log_{10}$ reduction in virus (i.e. 99.9% removal). The 90%, 95%, and 97.5% prediction intervals (PIs) are used to illustrate uncertainties in the predicted lifetimes based on statistical analysis (Yap et al., 2020).



It should be noted that most of the experimental studies highlighted above have been performed under laboratory conditions and not in steam rooms or saunas. In addition, many studies only consider heat inactivation in water, rather than when present in aerosols or respiratory droplets with no consideration of humidity, or on moist surfaces characteristic of saunas and steam rooms. Never-the-less, the impact of thermal inactivation on direct transmission between sauna and steam room users within the same session is likely negligible but thermal inactivation between sessions to mitigate cross-infection between different groups of users can be considered.
It has been noted that different cleaning regimes also affect the survival of the virus. However, vapours released from inappropriate chemical agents may also be a risk to human health in enclosed spaces with higher temperatures which promote chemical volatilisation.

Benefits of saunas and steam rooms: It is widely established that saunas and steam rooms may provide a range of benefits to human health ranging from improved mental health to improvements in physical health (Hussain et al., 2018; Kukkonen-Harjula and Kauppinen, 2012; Kunutsor et al., 2017; Laukkanen et al., 2018). The benefits and disbenefits of saunas and steam rooms can vary widely between individuals and have been proven to improve respiratory health in some circumstances (Pilch et al., 2013; Kunutsor et al., 2017).

However, when the indoor relative humidity (RH) is less than 40 percent, humans become more vulnerable to viral respiratory infections, thus the risk from SARS-CoV-2 virus in the inhaled air is increased. During the inhalation of low RH air, the mucus in our nose and throat becomes more viscous, diminishing the cilia's capability to expel viral particles. The low RH also compromises the immune system's ability to effectively respond to microorganisms (Taylor, 2020).

We acknowledge that there is a balance between minimising disease transmission risk while also supporting the wellbeing of individuals.

Transmission risk in saunas

Risk: **Low (Should mitigation conditions be met)**

Confidence: **Medium**

- As highlighted in the literature, it is possible for the virus to be rapidly de-activated at higher temperatures that are typically found in sauna environments. We acknowledge that there is some variation between the different studies with respect to virus inactivation time, and humidity will influence the survival time. However, heat by itself is not enough of a mitigation.
- If the sauna is single occupancy or a household bubble of individuals, and there is an effective decontamination period between users, then the risk of transmission to someone following on from them will be low.
- A grace period of at least 20 minutes with temperatures above 60°C between groups of individuals will help to reduce the transmission risk. This necessitates that the sauna has a good temperature controller that is regularly checked. The facility management should carry out a controlled trial to ensure that these temperature criteria can be reached effectively before opening to the public.
- Grace periods must also include the cleaning benches / surfaces / handles regularly with an appropriate detergent solution (See UK Gov. guidance: https://www.gov.uk/government/publications/covid-19-decontamination-in-non-healthcare-settings/covid-19-decontamination-in-non-healthcare-settings
- Face coverings should be worn in changing areas, however, we recommend that these be removed immediately prior to entering the sauna. This removal is due to the likely ineffective nature of damp masks at preventing viral release and also due to potential difficulties in breathing that damp masks might induce. Masks should be stored in a sealed plastic bag allowing immediate replacement upon leaving the room.
- The sauna should be pre-heated to specified temperature before use.
- The small size of most facilities will preclude effective social distancing and thus only sole occupants or individuals who are members of a household bubble should be admitted as a group.

- Hand hygiene/sanitation practices should be performed before and after the sauna. Users should sit on their own clean towel in the sauna, store in a separate bag and wash straight away without touching the users face or drying themselves
- The most important thing to avoid spreading the virus is not to visit a sauna if an individual has symptoms of COVID-19. It is important to emphasize that viral release in sneezing or coughing can reach another person without the virus having time to be killed, regardless of ambient temperature.
- The greatest risk of virus transmission in sauna environments is likely associated within the adjacent changing room areas and activities. Effective control measures should be practiced in these areas.

Transmission risk in steam rooms

Risk: **High**

Confidence: **Medium**

- As already highlighted, most steam rooms in the UK operate at temperatures up to 45^{o}C. The literature has stated that this temperature would not meet the temperature required to inactivate the virus and so could be a potential dangerous source of contamination.
- Unlike saunas, it is likely that long periods of time without human occupancy would be insufficient to effectively deactivate the virus (i.e. several hours between cohorts of users).
- Sterilisation of surfaces between cohorts is unlikely to be adequate or effective given the large amount or surfaces within steam rooms.
- The virus is likely to persist in the air as aerosols after an infected individual has left the steam room. These cannot be removed by sterilising surfaces. In an enclosed, unventilated space, this poses a direct risk to the next user.
- The small size of most steam rooms preclude social distancing and given the literature on temperature, speed of steam, and surface survivability; results in higher risks for users.
- Wearing masks in steam rooms would be ineffectual for the reasons highlighted above for saunas.
- Current guidance in Sweden is that steam rooms are high risk and are closed until further notice.
- Activities such as massages in steam rooms would also be seen as high risk as masks will be ineffective and social distancing cannot be maintained.

References

Abraham J.P., Plourde, B.D., Cheng, L. (2020). Using heat to kill SARS-CoV-2. Rev. Med. Virol. 30, e2115.

Ahlawat, A., Wiedensohler, A. and Mishra, S.K. (2020). An Overview on the Role of Relative Humidity in Airborne Transmission of SARS-CoV-2 in Indoor Environments. Aerosol Air Qual. Res. 20: 1856–1861.

Batéjat, C., Grassin, Q., Manuguerra, J.C., Leclercq, I. (2020). Heat inactivation of the Severe Acute Respiratory Syndrome Coronavirus 2. bioRxiv preprint doi: https://doi.org/10.1101/2020.05.01.067769.

Chin, A., Chu, J., Perera, M., Hui, K., Yen, H. L., Chan, M., Peiris, M., Poon, L. (2020). Stability of SARS-CoV-2 in different environmental conditions. The Lancet. Microbe, 1(1), e10.

Hussain, J., Cohen, M., Cooley, K., Kieran C. (2018) Clinical Effects of Regular Dry Sauna Bathing: A Systematic Review. Evidence-based Complementary and Alternative Medicine 2018, 1-30.

Kunutsor, S. K., Laukkanen, T., Laukkanen, J. A. (2017) Sauna bathing reduces the risk of respiratory diseases: a long-term prospective cohort study. European Journal of Epidemiology 32, 1107-1111

Kunutsor, S. K., Laukkanen, T., Laukkanen, J. A. (2017) Frequent sauna bathing may reduce the risk of pneumonia in middle-aged. Respiratory Medicine 132,161-163

Kukkonen-Harjula, K., Kauppinen, K. (2012) Health effects and risks of sauna bathing. International Journal of Circumpolar Health 65,195-205.

Laukkanen, J. A., Laukkanen, T., Kunutsor, S. K. (2018) Cardiovascular and Other Health Benefits of Sauna Bathing: A Review of the Evidence. Mayo Clinic Proceedings 93, 1111-1121.

Luo, C., Yao, L,. Zhang, Li, M.D., Yao, M., Chen, X., Wang, Q., 2020. Possible Transmission of Severe Acute Respiratory Syndrome Coronavirus 2 (SARS-CoV-2) in a Public Bath Center in Huai'an, Jiangsu Province, China. JAMA Network Open 3, e204583.

Pastorino, B., Touret, F., Gilles, M., de Lamballerie, X., Charrel, R.N. (2020). Heat Inactivation of Different Types of SARS-CoV-2 Samples: What Protocols for Biosafety, Molecular Detection and Serological Diagnostics? Viruses 12, 735.

Patterson, E.I., Prince, T., Anderson, E.R., Casas-Sanchez, A., Smith, S.L., Cansado-Utrilla, C., Solomon, T., Griffiths, M.J., Acosta-Serrano, Á., Turtle, L., Hughes, G.L. (2020). Methods of inactivation of SARS-CoV-2 for downstream biological Assays. J Infect Dis. 222, 1462-1467.

Pilch, W., Pokora, I., Szyguła, Z., Pałka, T., Pilch, P., Cisoń, T., Malik, L., Wiecha, S. (2020) Effect of a Single Finnish Sauna Session on White Blood Cell Profile and Cortisol Levels in Athletes and Non-Athletes. Journal of Human Kinetics 39, 127-135

Public Health England, (2020). SARS-CoV-2 inactivation testing: interim report https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/905783/HCM-CoV2-009-v3_Heat_Treatment_TCF-1.pdf

Saknimit, M., Inatsuki, I., Sugiyama, Y., Yagami, K. (1988). Virucidal efficacy of physico-chemical treatments against coronaviruses and parvoviruses of laboratory animals. Jikken Dobutsu 37, 341–345.

Shadloo-Jahromi, A., Bavi, O., Heydari, M.H., Kharati-Koopaee, M., Avazzadeh, Z. (2020). Dynamics of respiratory droplets carrying SARS-CoV-2 virus in closed

atmosphere. Results in Physics 19, 103482.
Wang, T.T., Lien, C.Z., Liu, S., Selvaraj. P. (2020). Effective Heat Inactivation of SARS-CoV-2. doi:10.1101/2020.04.29.20085498.
Watanabe, Y., Miyata, H., Sato, H. (1989) Inactivation of laboratory animal RNA-viruses by physicochemical treatment. Exp. Anim. 38, 305-311.
Yap, T. F., Liu, Z., Shveda, R. A., & Preston, D. J. (2020). A predictive model of the temperature-dependent inactivation of coronaviruses. Applied Physics Letters, 117(6), 060601.

Appendices

Data table from Public Health England report: SARS-CoV-2 inactivation testing: interim report July 2020.

Table of results

		Test 1: Titration post-treatment		**Test 2: Passage of samples in cell culture**	
		Mean virus titre (log_{10} pfu/ml)	Mean titre reduction (log_{10} pfu/ml)	Virus detected/ Virus not detected	Mean Ct value of baseline samples in SARS-CoV-2 PCR
56°C	0m	5.8	-	Virus detected (all replicates)	15.3
	15m	3.1	2.7	Virus detected (all replicates)	15.4
	30m	0.9	4.9	Virus detected (all replicates)	15.3
	60m	3.7	2.1	Virus detected (all replicates)	15.2
80°C	0m	5.7	-	Virus detected (all replicates)	16.5
	15m	2.2	3.5	Virus detected (≥1 replicate)	17.8
	30m	1.3	4.4	Virus detected (all replicates)	20.2
80°C (longer treatment times)	0m	5.6	-	Virus detected (all replicates)	16.0
	30m	1.5	4.1	Virus detected (≥1 replicate)	20.5
	60m	≤0.5	≥5.1	Virus detected (≥1 replicate)	25.5
	90m	≤0.5	≥5.1	Virus not detected	27.7
95°C	0m	5.7	-	Virus detected (all replicates)	16.5
	1m	≤0.5	≥5.2	Virus not detected	21.6
	5m	≤0.5	≥5.2	Virus not detected	22.0