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SARS-CoV-2 transmission risk in public toilets

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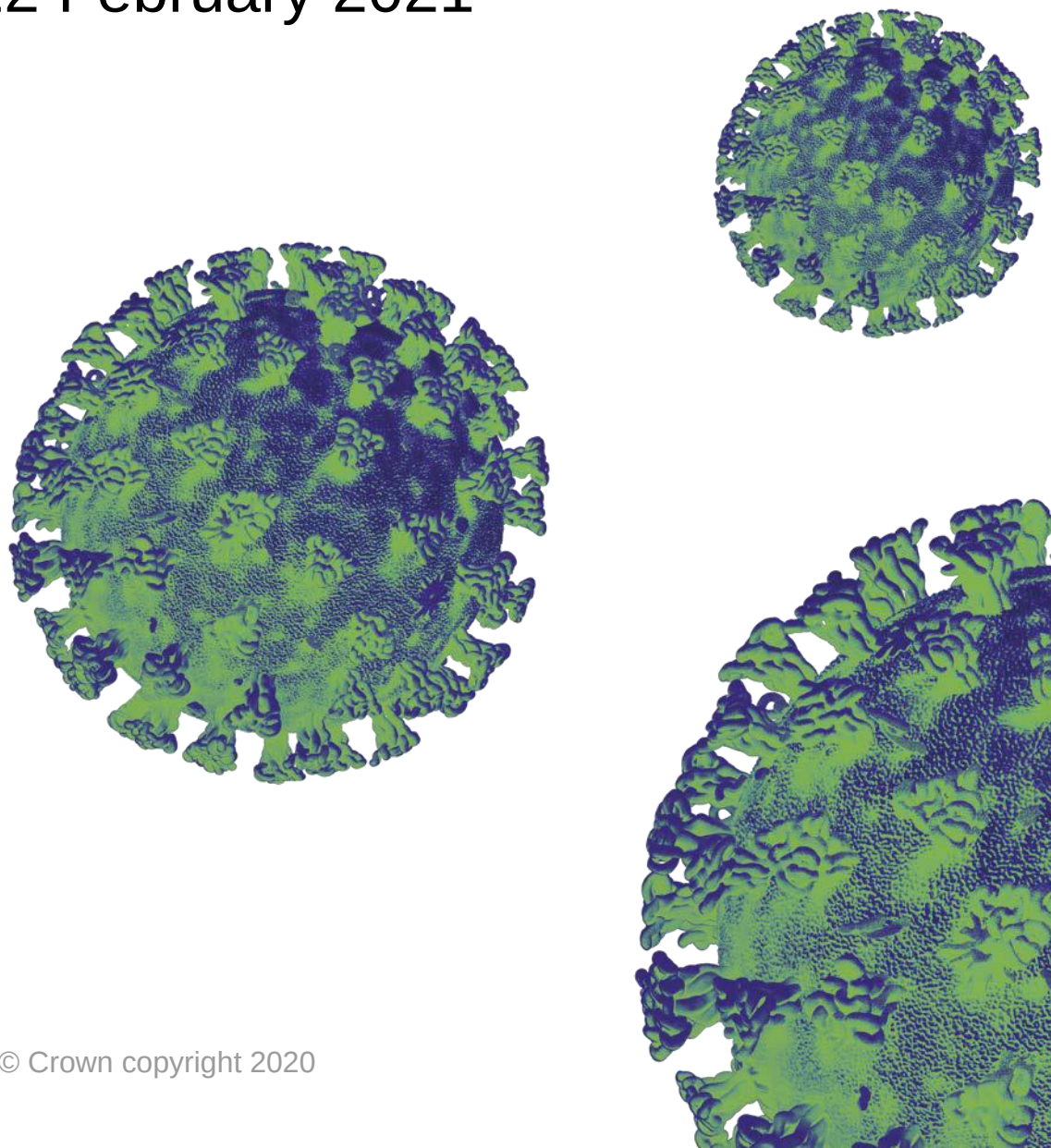

SARS-CoV-2 transmission risk in public toilets

Prepared for the Welsh Government Technical Advisory Group, Science and the Environment Subgroup

Purpose of paper: This paper was prepared to evaluate the evidence base surrounding the potential for COVID-19 transmission associated with individuals visiting public toilets.

Summary

Toilets pose a particular risk for COVID-19 transmission due to the following factors:

- the likelihood of poor ventilation, overcrowding and multi-occupancy (i.e. high density, confined spaces);
- lots of contact surfaces (handles, taps, etc) where the virus may survive and pass from one person to another;
- the presence of cold and wet surfaces which are conducive to viral survival;
- use of air dryers and flushing open toilets that can all contribute to aerosol transfer of the virus to the air and contamination of adjacent surfaces;
- the potential aerosolization of urine and faces containing SARS-CoV-2 during the use of urinals and toilets;
- the possibility of poorly maintained toilets;

Whilst evidence for viral shedding in faecal matter and urine remains very incomplete, particularly in non-clinical cases, infectious viral particles have been detected in faeces and urine. Consequently, taking a precautionary principle approach we detail a number of interventions that can be used to help mitigate the potential for transmission in public toilets.

Introduction

Public toilets are a potential point of transmission because they are areas of high traffic, are used by multiple users, with both surface and aerosol transmission potential. Public toilets can have poor ventilation[1] and poor maintenance, they can be crowded with social distancing hard to maintain, have many touch points and points of potential aerosol transmissions such as hand dryers and open flushing toilets and urinals. However, public toilets are important public infrastructure, they are vital for the maintenance of accessible, sustainable and comfortable urban spaces (Greed et al. 2004).

[1] The WHO currently only recognise airborne transmission risk in specific aerosol generating procedures in health care settings. However, there is evidence that aerosol microdroplets could be released from infected persons with this risk being particularly significant in enclosed indoor spaces with poor ventilation (Marowska and Milton 2020; Somsen et al. 2000). Clearly enclosed public toilets would fall into this category.

Any enclosed and poorly ventilated space poses a risk for aerosol transmission. However, there may be an additional risk in toilet settings, which is, at this stage, hard to quantify. The RNA of SARS-CoV-2 has been detected in both urine and faeces (e.g. Tian et al. 2020; Cherradi et al. 2020; Heneghan et al. 2020[2]; Wang and Xu 2020; Xiao et al. 2020b; Zhang et al. 2020; Sun et al. 2020b). However, the evidence for the presence of large amounts of infectious (viable) viral particles in faeces and urine and thus the potential to cause active infection is low (Phillis et al. 2021); viral shedding in urine is rare, detectable in an estimated 3–4% of positive tested patients (Trypsteen et al., 2020), one study has detected infectious viral particles in urine (Sun et al. 2020b) and three studies have cultured viral samples from faecal samples (Wang and Xu et al. 2020; Xiao et al. 2020b; Zhang et al. 2020; WHO 2020). We further note that in a single-subject study of the presence of viral RNA and SARS-CoV-2 in a covid positive patient (a 31 year old male) viral RNA was detected in semen and urine samples 8-days after a positive covid test, but the presence of SARS-CoV-2 was not detected in either samples (Paoli et al 2020). The first covid patients in the USA was noted to experience GI symptoms and a study on that patient notes that viral nucleic acids of stool samples later tested positive (Holshue et al. 2020). In general, the presence of (non-covid) viral RNA is reported in a high percentage of patients via faecal testing (Ling et al. 2020), however, the percentage of patients with the presence of viral RNA detectable in urine is much lower (Trypsteen et al., 2020; Paoli et al. 2020).

Coronaviruses has also been found to have the ability to remain infectious for long periods in water and sewage inoculated with viable virus at high levels (Ahmed et al. 2020, Dancer 2020). Public toilets thus have several possibly sources of transmission risk of a variety of likelihoods. A natural progression of this line of evidence is to consider public toilets potential transmission points via both direct and indirect transmission (e.g. aerosol/airborne, direct droplet and surface transmission). A conservative approach would also assume the (low) possibility that one potential source is transmission of active viral particles via faecal and urine aerosols. For these reasons public toilets warrant specific guidelines to ensure their safe operation as an essential part of public infrastructure.

Evidence

Evidence has been found for potential transmission events in toilets (e.g. Cai et al. 2020) whilst the background evidence around the potential for transmission of active

[2] We note that the pre-print article (as of December 2020) Heneghan et al. (2020), a meta-analysis study (not currently peer reviewed) found that "*there is observational and mechanistic evidence to support the hypothesis that SARS-CoV-2 can infect and be shed from the human gastrointestinal tract*". This article was, at the time of writing, in open review and itself makes reference to papers also in open review. The article pre-print notes "*This article is a preprint and has not been peer-reviewed It reports new medical research that has yet to be evaluated and so should not be used to guide clinical practice.*" This evidence should be re-reviewed once in print. Other evidence for shedding of active virus from the human GI-tract is limited.

viral particles from human faecal matter and urine is growing (e.g. Dancer 2020; Gu 2020; He et al. 2020; Wang and Li 2020; Xiao et al. 2020a and 2020b). Dancer (2020) quoting Wong et al. (2020) state that testing (PCR), on one study, found a 40% occurrence of positive tests in faecal samples from covid-positive patients with women, and those with a more serious version of the disease, having a higher rate of positive samples. The difference between viral particle shedding and infectious viral particle shedding is important to note, however. In one study, on the likelihood of faecal-oral transmission, only broken sections of the viral genetic code could be detected in faecal samples from infected patients (Wolfel et al. 2020). It is not possible for such particles to cause infection in others via aerosol transmission. The detection of viral RNA in faecal samples from infected patients does not necessarily indicate active replication of the virus in the gastro-intestinal tract. However, as noted above, three studies have cultured SARS-CoV-2 from stool specimens (Wang and Xu 2020; Xiao et al. 2020b; Zhang et al. 2020).

Faecal viral shedding is thought to continue during the lifetime of the disease in an individual such that asymptomatic or post symptomatic individuals could shed viral particles when using public toilets. One study found that faecal shedding of virus particles continued to occur even after nasopharyngeal tests were negative (Cheung et al. 2020). In this meta-analysis of 4,243 positive patients, 48% had positive tests for viral particles in stool samples. Of positive cases detected after loss of the virus from respiratory tests, 70% still tested positive for the viral RNA in faecal samples (Cheung et al. 2020). However, it is important to distinguish between the detection of active viral particle in stools and faecal matter and the presence of faecal to oral transmission. Detection has occurred widely (e.g. Ding et al, 2020), but evidence of faecal to oral transmission is not confirmed (e.g. Gandhi et al. 2020).

There is evidence for the virus surviving for several hours in faeces and several days in urine (Foladori et al. 2020; Dancer 2020; Liu Yongjian et al. 2020). However, the likelihood of faecal shed viral particles having the potential to cause infection is probably very low. The presence of viral RNA is frequently identified in faeces and urine, but there is no definitive evidence this poses a common route of transmission (e.g. Wolfel et al. 2020; Gandhi et al. 2020; Phillis et al. 2021).

Whilst a discussion of the expression of viral particles in human biological samples goes beyond the scope of this paper we note that the limited evidence base on whether or not infection-causing viral particles are shed in human urine and faeces to the extent at which they pose a transmission risk, is problematic. The impression given from the literature is that, whilst the evidence for live viral particles in human waste is limited, that could well be due to the lack of studies specifically measuring to detect SARS-CoV-2 in faeces or urine (as opposed to simply testing for the presence of viral RNA which is not an indication of active covid viral material). The complexity of the problem is well summarised in comment pieces from Gu et al. (2020) and Patel (2020). McDermott et al. (2020) highlight why the issue, despite the

limited evidence via detection, is of concern "*While little to no research is available on the production of infectious bio-aerosols containing specific pathogens, including SARS-CoV-2, the presence of pathogens such as* Clostridioides difficile *in hospital air is substantially increased by toilet flushing"*

Transmission sources in public toilets

Under laboratory conditions, the virus has been found to persist on stainless steel for days (up to 72 hours) and glass, metal and plastic for up to 9 days (Gandhi et al. 2020, Van Doremalen et al. 2020, Kampf et al. 2020). Hu et al. (2021) in a study of surface contamination in domestic settings found a relatively high positive test rate for the presence of SARS-CoV-2 on environmental surfaces in domestic bathrooms.

In terms of surface decontamination one study finds surfaces can be cleaned with 62–71% ethanol, 0.5% hydrogen peroxide or 0.1% sodium hypochlorite within 1 minute. Other biocidal agents such as 0.05–0.2% benzalkonium chloride or 0.02% chlorhexidine digluconate are less effective (Kampf et al. 2020)

The WHO recommends:

- hand hygiene stations are available within 5 m of any public toilet,
- flush toilets should operate properly and have functioning drain traps,
- toilets should be flushed with the lid down to prevent droplet splatter and aerosol clouds (WHO 2020).

In a survey of toilet and non-toilet touch points in a hospital, toilets dominated as a source of positive samples (sites with positive COVID-19 particulate detectable included: ward door handles, patient toilet seat, bathroom door handle, bathroom washbasin tap lever, bathroom ceiling fan door; *ibid*).

The WHO recommend "toilets should be flushed with the lid down to prevent droplet splatter and aerosol clouds" (WHO 2020). Two studies present an argument for faecal-aerosol transmission risk being a possibility in toilets. In one study 9 infected individuals across 3 families, who lived in adjacent flats in Wuhan, were thought to have contracted infections via bathroom vents (Kang et al. 2020). The families lived in vertically aligned flats connected by drainage pipes. The positive infections and the locations of test-positive surface and environmental tests were consistent with vertical spread of viral aerosols via the bathroom vents and stack pipes (*ibid*). Gandhi et al. (2020) note the evidence of contamination after toilet flushing, but consider this transmission method to be rare.

A widely cited study (Wang and Li 2020) found there to be a risk of transmission from flushing of urinals because of the turbulent flow caused by the flush and its ability to spread particles. Whilst the study was widely cited in the popular press (e.g.

Link) it, in fact did not detect aerosol transmission from flushing but took a computational fluid dynamics approach to explore and visualize (model) the characteristics of fluid flow during toilet flushing. Further modelling studies indicated between forty and sixty percent of viral particles generated by toilet flushing were able to reach above the toilet seat level (without the seat lid down) (Li et al. 2020). However, one press study (non-peer reviewed) does report a case of infection from a public toilet in Beijing (Link here). It is of note that the only source of the public toilet transmission information in the Beijing case is a press report but that event has been cited in papers (e.g. Wang and Li 2020) as evidence of the potential of public toilet transmission events. A further investigation of transmission through toilet pipes in Hong Kong (Link here) is noted in a WHO report on water, sanitation, hygiene and waste management (WHO, March 2020).

In the case of the Hong Kong study there is (limited) evidence of a cluster of COVID-19 cases related to faulty plumbing and a faecal source of viral aerosol (Hong Mei house cluster; Nardell and Nathavitharana 2020). In this case the issue is cited to have been poor quality toilet facilities. It is reasonable to take a conservative approach and assume poorly maintained public toilet facilities could pose an added transmission risk.

Lower temperatures in the winter have been argued as not causal to increasing the aerosol stability of the virus because the mean winter temperature in the UK is around 10ºC which is within the range at which the virus has been found to be stable in terms of decay rate (Dabisch et al. 2020). However, the above study was small in scale with levels of temperature treatment set coarsely at +10ºC, +20ºC, +30ºC, and +40ºC. For Nov-Mar the average maximum temperature in Wales (1971-2000) is <+10ºC. Caution is needed in extrapolating viral decay rates at under 10ºC from the above study. Moreover, the stability of viral droplets within the atmosphere may also be influenced by colder winter temperatures (Ng et al. 2020 [preprint]). The research base is problematic on this in that +10ºC is the commonly adopted end member temperature in studies. With many respiratory viruses being seasonal and winter temperatures for densely inhabited regions of the world often well below this temperature, this lower benchmark is questionably relevant in many geographical areas. A cautious approach would assume lower temperatures in winter in Wales could impact droplet stability, but further research is needed.

However, the risk of contaminated surface transmission on the sort of cold, wet surfaces found in public toilets may increase in winter. SAGE find that environmental conditions in unheated indoor environments (due to lower temperatures) may increase viral persistence on surface (SAGE report here, O'Reilly et al. 2020).

If infectious viral particles are present, we would summarise the greatest transmission risk potential in public toilets to be:

- Splashes onto toilet surfaces (of faecal or urine matter) or around sinks (wastewater splashes etc), followed by touch transmission.
- Aerosolization of waste material during toilet flushing or via broken pipes/poor quality plumbing or via hand dryers.
- Touch transmission around points such as sinks, handles, flushes, dryers.
- Standard aerosol transmission in poorly ventilated and crowded indoor toilets where social distancing is difficult to maintain.

Cleaning

Welsh Government provides statutory guidance on decontamination in non-healthcare settings which, whilst relevant to public toilets, is not specifically for public toilets. Whilst there are national guidelines, responsibility falls with local authority/councils/management teams to manage their toilets in accordance with this.

Workplace return guidelines (link here) recommend:

- Set clear cleaning guidance, with increased frequency of cleaning. Use normal cleaning products, paying attention to frequently hand touched surfaces, and consider use of disposable cloths or paper roll to clean all hard surfaces. Care should be taken with cleaning larger toilet blocks and the cleaning schedule should be visible.

Summarising from these sources we would recommend twice daily cleaning of touch points is adopted as standard using one of the cleaning product criteria recommended in that guidance:

- a combined detergent disinfectant solution at a dilution of 1,000 parts per million available chlorine (ppm av.cl.)
- a household detergent followed by disinfection (1000 ppm av.cl.). Follow manufacturer's instructions for dilution, application and contact times for all detergents and disinfectants
- an alternative disinfectant is used within the organisation ensure that it is effective against enveloped viruses.

Further detail on the establishment of a cleaning protocol is available from the WHO here (Link here). We note the Welsh Government adopted guidelines on cleaning products above are in line with WHO guidance. Care should be taken to maintain familiarity with the most up to date Welsh Government/PHE guidance on cleaning protocols in non-clinical settings (e.g. Link here)

Co-ordinating guidelines.

We note there are guidelines on cleaning toilets in multiple places.

- Guidelines on toilets in Council properties (link here).
- Guidance on toilets in offices and contact centres (link here)
- Public Health England's advice on cleaning in non healthcare settings is also of relevance (link here: PHE, Cleaning in Non-Healthcare Settings Outside the Home).

The different sources give different guidelines and we would recommend these are aligned with one set of best practice guidelines for any toilets used by the public.

Summary

Toilets pose a particular risk because of:

- the likelihood of poor ventilation, overcrowding and multi person use at the same time;
- the increased possibility for aerosol transmission at urinals and from toilet flushing;
- cold and wet surfaces;
- the possibility of poorly maintained toilets;
- use of air dryers and flushing open toilets that can all contribute to transmission on surfaces and via aerosol.

Whilst evidence for viral shedding in faecal matter is not conclusive, active particles can be detected in faecal matter long after a patient has negative nasal swab tests and a small number of studies have cultured the virus from urine/faecal samples. With evidence of transmission events around bathrooms and toilets it is wise to ere on the side of caution and assume a need to limit the potential for additional aerosol transmission points in toilet settings (e.g. Nardell and Nathavitharana et al. 2020; WHO March 2020; Wang and Li et al. 2020)

Aerosol transmission is potentially reduced in the case of toilet stalls by the fact that they are sole use, there is, however, a potential risk with aerosol transmission from flushing urinals. We note that the only evidence of this risk comes from an unsubstantiated press article (Graham 2020) citing transmission from a public toilet in Beijing and two other academic studies on the possible transmission from flushing urinals, but these are model based and do not include detection. Further, the models have not been validated with any type of virus. However, we note that an appropriate and conservative control measure would be to seal off urinals in male toilets, leaving only stalls available.

The WHO recommends hand hygiene stations (either hand sanitizer or sinks with soap and water) are available within 5 m of public toilets, that flush toilets should

operate properly and have functioning drain traps and the toilet should be flushed with the lid down to prevent droplet splatter and aerosol clouds (WHO, March 2020).

There is some evidence of transmission from faulty sewage pipes and as such the poor condition of public toilets might pose an added risk.

We note the UK Ministry of Housing, Communities and Local Government issued the following guidance on public toilets in multi-purpose community facilities on November 17th 2020. (Link here).

- Using signs and posters to build awareness of good handwashing technique, the need to increase handwashing frequency and to avoid touching your face, and to cough or sneeze into a tissue which is binned safely, or into your arm if a tissue is not available.
- Consider the use of social distancing marking in areas where queues normally form, and the adoption of a limited entry approach, with one in, one out (whilst avoiding the creation of additional bottlenecks).
- To enable good hand hygiene and to consider making hand sanitiser available on entry to toilets where safe and practical, and ensure suitable handwashing facilities including running water and liquid soap and suitable options for drying (either paper towels or hand driers) are available.
- Setting clear use and cleaning guidance for toilets, with increased frequency of cleaning in line with usage. Use normal cleaning products, paying attention to frequently hand touched surfaces, and consider use of disposable cloths or paper roll to clean all hard surfaces.
- Keep the facilities well ventilated, for example by fixing doors open where appropriate and opening windows.
- Special care should be taken for cleaning of portable toilets and larger toilet blocks.
- Putting up a visible cleaning schedule can keep it up to date and visible.
- Providing more waste facilities and more frequent rubbish collection.

There are clear steps that can be taken to minimise surface and aerosol transmission in public toilets. We would summarise these as:

1. Reducing touch points.
    - Swing doors on the toilet building entrance.
    - Automatic soap dispensers/taps etc.
    - Paper towels instead of hand dryers.
2. Reduce density of usage
    - Control numbers of people using the toilet at any one time and leave time in between users.
    - Consider reducing the density of available stalls/urinals/sinks.
3. Reducing opportunities for aerosol transmission.
    - Ensure plumbing and pipes are maintained and functioning adequately. Give a reporting procedure for faults.

- Toilet lids.
- Ventilate the toilets by opening windows and entrance doors and allow direct sunlight in via open windows, where possible.
- Consider closing urinals, only allow use of toilet stalls. We suggest this should be judged on a case by case basis. If closing urinals would lead to more crowded use of the facilities or increase touch points, we would not recommend closing urinals.
- Signage to encourage closing the lid before flushing and encourage face covering wearing and hand hygiene etc.

4. Hygiene.
    - Hand cleaning signage.
    - Availability of hot water, soap, hand gel, paper towels.
5. Increasing cleaning regularity.

Transmission risk in public toilets and recommendations for safe use

Risk	**Score**	**Confidence**	**Mitigations (recommendations)**
Transmission via aerosol from public toilets	MEDIUM (if recommendations followed)	MEDIUM	• Public bathrooms should have extraction fans running to facilitate air movement (SAGE recommendation, Link). • Install lids on public toilets. We note this is an issue with accessible bathrooms which do not tend to have toilet lids. • Urinals should be closed, offering usage of toilet stalls only as there is an increased physical barrier to transmission in toilet stalls. Closure of mid-point stalls and basins will also reduce occupancy levels of public bathrooms. We note caution if this causes additional queueing in which people may be unable to socially distance. • We note Welsh Government guidance on Providing Safe Toilets during the pandemic which should be being followed at Local Authority level. • We recommend a regular (twice daily) cleaning of public toilets using recommended cleaning guidelines. Further detail on the establishment of a cleaning protocol is available from the WHO here (Link), we note the Welsh Government adopted guidelines on cleaning products above are in line with WHO guidance. • We recommend disconnecting air dryers and replacement with disposal paper towels.

			• We recommend hot water provision for hand washing. • We recommend enhanced procedures to ensure plumbing and pipes are maintained and functioning and a notice on how to report faults.
Transmission via surface contamination in public toilets	LOW (if recommendations are followed)	MEDIUM	• WHO recommendations on hand sanitizing stations (preferably with warm water) flushing, drainage and lids should be adopted. • Where possible touchless features such as taps, soap dispensers, towel dispensers should be adopted. • We also suggest two-way swing doors where possible, on the main toilet entrance, to reduce door handle touch points.
Transmission risk general	LOW (if recommendations are followed)	Medium	• Control numbers of people using the toilet at any one time and leave time in between users. • Ventilate the toilets and allow sunlight in where possible. • Signage to encourage mitigating behaviours; closing the lid before flushing, correct hand hygiene.

Resources and references*

*includes additional references and resources to those cited in the above. An indication is given if the resource is either grey literature or in preprint form (un peer reviewed).

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Resource guidance notes.

Resources	*Link*
WHO report on water, hygiene and waste management .	https://apps.who.int/iris/bitstream/handle/10665/331305/WHO-2019-NcOV-IPC_WASH-2020.1-eng.pdf
Paper on faecal-oral transmission in India.	https://www.jppcm.org/article/2020/6/2/18-19
Paper on the possibility of GI/faecal transmission.	https://onlinelibrary.wiley.com/doi/abs/10.1111/apt.15731?casa_token=XlDDs_iDLUsAAAAA:gUsl9VKaJoRF4MruDA711QHvBZp7B0YhijdYA-yO6zWdUtd1LCZPEx_sPjQx-ktTuEkshKNnHyj9OP8
Covid as a digestive disease.	https://www.researchgate.net/profile/Younes_Cherradi2/publication/341135419_CoVID-19_a_digestive_disease/links/5ebd5e10299bf1c09abbf761/CoVID-19-a-digestive-disease.pdf
How can airborne transmission indoors be minimised.	https://www.sciencedirect.com/science/article/pii/S0160412020317876
Popular (National Geographic) report on public toilet transmission.	https://www.nationalgeographic.co.uk/science-and-technology/2020/06/could-flushing-a-public-toilet-really-spread-covid-19
Viral transmission in urinals.	https://aip.scitation.org/doi/full/10.1063/5.0021450 https://publishing.aip.org/publications/latest-content/flushing-toilets-create-clouds-of-virus-containing-particles/
COVID-19a considerations for the waste and waste water industry.	https://www.sciencedirect.com/science/article/pii/S2666016420300049
Avoiding COVID-19 aerosol transmission.	https://arxiv.org/abs/2005.10988
Indirect transmission in clusters in china.	https://wwwnc.cdc.gov/eid/article/26/6/20-0412_article?te=1&nl=the-morning&emc=edit_nn_20200528
Scottish report on public toilets.	https://www.gov.scot/publications/coronavirus-covid-19-public-and-customer-toilets-guidance/pages/hygiene-measures/
Can a toilet promote viral transmission?	https://aip.scitation.org/doi/abs/10.1063/5.0013318%40phf.2021.FATV2020.issue-1?casa_token=o9fvVxXn-wUAAAAA:wUHu8LUsr6hbbyPNwxdEpn4UtYku3n2-IEUSLZOfy2Z5uUoqY94xLmNjLXHesgG-U-

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On viral particle shedding in faeces and urine.	https://www.sciencedirect.com/science/article/pii/S0048969720348932?casa_token=R1CR_4Ki6QMAAAAA:0sS94L6neTa_ZZ6jTzDOmIHR--I7uQr8hJR9_lx7VkR3oCF5rT50x0Wwi9ZLDxHNpTu3xVTDNg
On contact transmission in shared services facilities.	https://www.researchsquare.com/article/rs-89199/latest.pdf
Aerosol transmission systematic review.	http://expeditiorepositorio.utadeo.edu.co/handle/20.500.12010/11891
Virus survival rates in different conditions.	https://www.nature.com/articles/s41421-020-00191-9
Aerosol and surface stability of the virus.	https://www.medrxiv.org/content/10.1101/2020.03.09.20033217v2
Increasing relative humidity and temperature reduces viral survival times on surfaces.	https://msphere.asm.org/content/5/4/e00441-20
COVID-19 in the environment - surfaces, aquatic systems and management.	https://www.sciencedirect.com/science/article/pii/S0048969720362276
Toilets dominate the COVID-19 detection environment in hospitals - paper (preprint).	https://www.sciencedirect.com/science/article/pii/S0048969720352396?casa_token=zobdjUZtIuQAAAAA:klQIq-ADRPtmfhnWyYK2lKy9frUaACK-nZ_BqggZudkYoX-4ugZDakpz8ji1MW-smm3xTpXifmU
On using light in indoor spaces to limit transmission.	https://pubs.acs.org/doi/abs/10.1021/acsnano.0c04596
Review of evidence on covid transmission in faecal matter - paper, preprint	https://www.medrxiv.org/content/10.1101/2020.08.04.20168054v1
Survival of Coronaviruses in water and wastewater. Discussion of the implication of lower winter temperatures and prolonged water droplet survival on cold, wet surfaces in public toilets.	https://www.ncbi.nlm.nih.gov/pmc/articles/PMC7091381/pdf/12560_2008_Article_9001.pdf