SARS-CoV-2: The Growing Case for Potential Transmission in a Building via Wastewater Plumbing Systems

The coronavirus disease 2019 pandemic is a stark reminder of the role people and buildings play in the transmission of viruses. The pandemic has led us to review all building systems, particularly those involving airflow, and all procedures and system phenomena that produce aerosols. There is a growing body of evidence that built environment systems contribute to the spread of severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2). In their current report, Kang and colleagues (1) add wastewater plumbing systems to the catalogue of potential transmission pathways in buildings (1).

Viral transmission dynamics fall into 2 main groups: direct contact between an infected and a susceptible person and indirect contact by a susceptible person with virus shed in droplets or aerosols from an infected person. Indirect transmission occurs when a susceptible person touches a surface contaminated by droplets or aerosols containing infectious virus and then touches their mouth or nose, or by inhaling infective droplets or aerosols from environmental systems.

Kang and colleagues report a case in which transmission probably occurred by indirect contact in an apartment building: Viral particles seem to have been carried on air streams within the pipe network and entered the interior of the building from the wastewater system. Aerosols, typically less than 5 µm in diameter, are light enough to be carried in air, whereas larger droplets tend to fall out of the air before traveling long distances. Kang and colleagues describe a situation in which infectious aerosols may have been formed as the result of turbulent flows within a wastewater plumbing system containing virus-laden feces.

Several studies have investigated the shedding of viral particles in feces (2, 3). Most of these studies looked for evidence of viral RNA in fecal samples; however, the transmission route that Kang and colleagues propose relies on the infectivity of the virus in fecal droplets and aerosols. Although some evidence exists for this, it is weak and based on small studies and case reports. Establishing infectivity is much more complicated than establishing the presence of viral RNA, so more definitive evidence is anticipated to emerge with time.

Work by my team identified the mechanisms involved in transmission dynamics between 2 different interconnected yet separate spaces within a building (4, 5). The work was in response to the World Health Organization (WHO) report in 2003 (6) of a SARS outbreak in Amoy Gardens, a housing complex in Hong Kong, which led to the infection of 321 persons and resulted in 42 deaths (7, 8). The WHO hypothesized that empty U-traps in the plumbing system created a pathway for virus-laden droplets and aerosols to enter bathrooms and spread the infection as residents touched contaminated surfaces. The transmission pathway was aided by mechanical bathroom extract fans and favorable outdoor air conditions, which allowed an additional transmission pathway on the outside of the building.

The Amoy Gardens case highlights the challenges of epidemiologic studies on transmission in high-rise buildings. Kang and colleagues faced similar issues as they struggled to piece together the transmission between different floors in the building they investigated. One of the challenges highlighted in their article is the presence of evidence after the event. They emphasized that in the apartments where the suspected infections occurred, efforts to disinfect the bathroom may have destroyed the evidence in the U-traps. They verified this in apartments 802, 1602, 2102, and 2702, where tracer gas released into the wastewater drainage stack at apartment 1502 was detected in each unit, thus confirming that no water was present in the U-traps. The authors' use of closed circuit television footage to assess movement of the building's occupants, along with the strict restrictions on movement by the authorities, supports the conclusion that infection spread through the wastewater system. However, the authors cast appropriate caution about their findings and have not overstated the evidence.

Although evidence is building, it is not yet strong enough to warrant wide-scale intervention—but does warrant some precautions. The authors and others working in this field highlight the possibility that a virus, such as SARS-CoV-2, may be transmitted in the manner described by Kang and colleagues (1). However, building wastewater systems are a potential reservoir for many other viruses and bacteria; even in the absence of SARS-CoV-2, this is a cause for concern. After the SARS outbreak of 2002 to 2003, efforts to formally regulate wastewater systems—similar to regulation of water supply systems to control such pathogens as *Legionella*—failed to gain traction. Other innovations developed at that time to deal with air pressure surges, a common cause of empty U-traps in high-rise buildings, are currently used in some locales but are not common practice (9). In another development, a method was invented to determine whether a system is sealed, but this likewise has not been used widely (10).

In conclusion, Kang and colleagues add to the growing body of evidence that wastewater plumbing systems, particularly those in high-rise buildings, deserve closer investigation, both immediately in the context of SARS-CoV-2 and in the long term, because they may be a reservoir for other harmful pathogens.

This article was published at Annals.org on 1 September 2020.

Michael Gormley, PhD, CEng
Heriot-Watt University, Edinburgh, United Kingdom

Disclosures: Disclosures can be viewed at www.acponline.org/authors/icmje/ConflictOfInterestForms.do?msNum=M20-6134.

Corresponding Author: Michael Gormley, PhD, CEng, Heriot-Watt University, Room 1.27, Edwin Chadwick Building, Riccarton Campus, Edinburgh EH14 4AS, United Kingdom; e-mail, m.gormley@hw.ac.uk.

Ann Intern Med. doi:10.7326/M20-6134

References

1. **Kang M, Wei J, Yuan J, et al.** Probable evidence of fecal aerosol transmission of SARS-CoV-2 in a high-rise building. Ann Intern Med. 2020. [Epub ahead of print]. doi:10.7326/M20-0928
2. **Chen C, Gao G, Xu Y, et al.** SARS-CoV-2-positive sputum and feces after conversion of pharyngeal samples in patients with COVID-19 [Letter]. Ann Intern Med. 2020;172:832-834. [PMID: 32227141] doi:10.7326/M20-0991
3. **Ding S, Liang TJ.** Is SARS-CoV-2 also an enteric pathogen with potential fecal-oral transmission? A COVID-19 virological and clinical review. Gastroenterology. 2020;159:53-61. [PMID: 32353371] doi:10.1053/j.gastro.2020.04.052
4. **Gormley M, Aspray TJ, Kelly DA, et al.** Pathogen cross-transmission via building sanitary plumbing systems in a full scale pilot test-rig. PLoS One. 2017;12:e0171556. [PMID: 28187135] doi:10.1371/journal.pone.0171556
5. **Gormley M, Aspray TJ, Kelly DA.** COVID-19: mitigating transmission via wastewater plumbing systems [Letter]. Lancet Glob Health. 2020;8:e643. [PMID: 32213325] doi:10.1016/S2214-109X(20)30112-1
6. **World Health Organization.** Consensus document on the epidemiology of severe acute respiratory syndrome (SARS). Accessed at https://apps.who.int/iris/handle/10665/70863 on 31 August 2020.
7. **Hung HCK, Chan DWT, Law LKC, et al.** Industrial experience and research into the causes of SARS virus transmission in a high-rise residential housing estate in Hong Kong. Building Services Engineering Research and Technology. 2006;27:91-102.
8. **McKinney KR, Gong YY, Lewis TG.** Environmental transmission of SARS at Amoy Gardens. J Environ Health. 2006;68:26-30; quiz 51-2. [PMID: 16696450]
9. **Swaffield JA, Campbell DP, Gormley M.** Pressure transient control: part I - criteria for transient analysis and control. Building Services Engineering Research and Technology. 2005;26:99-114. doi:10.1191/0143624405bt119oa
10. **Kelly DA, Swaffield JA, Jack LB, et al.** Pressure transient identification of depleted appliance trap seals: a pressure pulse technique. Building Services Engineering Research and Technology. 2008;29:165-81. doi:10.1177/0143624408091321