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COVID-19: Complexities in understanding transmission pathways through sanitary systems in high-rise buildings.

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Commentary

The article published recently in the Lancet Global Health, COVID-19: mitigating the transmission *via* wastewater plumbing systems [1] is a synthesis of 17 years of study into the spread of disease as a result of defects in the wastewater plumbing system (sanitary system) within buildings, however it the issues associated with this mode of transmission are more appropriately attributed to tall (high-rise) or complex buildings [2].

Transmission of viruses through sanitary systems has not often been considered by infection control personnel as a significant risk to the inhabitants of a building; however the events in one apartment complex in Hong Kong changed that. Hong Kong was at the epicentre of the SARS outbreak in 2002-2003 where in one 41 storey building there were 321 cases of which 42 led to death. Investigations at the time, led by the WHO, focused on the building topology and its influence on the spread of the virus. One significant finding, reported in the final consensus document [3], identified the sanitary wastewater system as contributing to the super-spreading event. ‘Virus-laden droplets’ emerging from empty U-Bends, mainly floor drains in bathrooms, facilitated the transmission. The process was aided by room ventilation which drew air from the sanitary system.

Since these events in 2002-2003, our research has focused on investigating mechanisms of cross transmission. In addition to this we have looked at mitigation and monitoring strategies and investigating pathogen reservoirs within the system. This should have been a game-changer for building maintenance and the wastewater plumbing industry, however this sector is very slow to change and little happened once SARS had disappeared.

A series of investigations followed to establish the public health risk associated with plumbing from a range of standpoints; water conservation [4,5] innovations in pressure equalisation within the system (a cause of empty U-Bends) and identification of the wastewater plumbing system as a reservoir for harmful pathogens [6-9].

In response to the lack of evidence relating to this mechanism of cross-transmission, a research programme [10,11] was initiated to investigate the mechanisms of cross-transmission within these systems. The work resulted in definitive proof that this transmission pathway was a *via*ble means to transport pathogens under the same defect conditions found in the SARS case in Hong Kong. Contamination of all surfaces in the bathroom were detected. The defects found in the Hong Kong case were not unique to that building or that geographical location. Our work has identified defects in, may tall and complex buildings over the years.

One important factor identified from the work was how the whole system was connected by a network of pipes which means that all parts of the building are effectively connected together and air can flow between them all and the only protection against ingress of contaminated air from one part of a building to another is the water trap seal or U-Bend. [11].

This interconnectedness of the system and the vulnerability of the seal between the interior of the building and the wastewater plumbing and sewer network (ostensibly, the water trap seal) means that the risk of transmission is higher during a pandemic. Water trap seals are vulnerable for a variety of reasons including;

System over-use - which causes pressure surges that can blow water out of U-Bends (positive pressure surges) or suck water out of U-Bends (negative pressure surges),

System under-use - and/or high ambient temperatures (both lead to evaporation).

Once this seal is lost there is a direct pathway between the wastewater and sewer system and the interior of the building. When a building has a high number of infected people, in a hospital for example, then the viral load in the system will increase and the likelihood of higher concentrations in the airflow which may enter the interior. This may also be an issue in tall buildings when people are self-isolating and systems are being used to (or beyond) their maximum capacity.

The paper identifies a credible transmission pathway risk associated SARS-CoV-2, particularly in tall buildings during this pandemic. With some systems experiencing peak usage due to self-isolation, and others being under-used as many commercial buildings are closed. There will be a real engineering challenge to re-open buildings following this

unusual lock-down period. The paper charts an understanding which has been built-up since the SARS pandemic in 2002-2003. Lessons could have been learned from that experience to include infection control in wastewater system design and maintenance as standard, however this was largely ignored. The challenge now it to ensure that the waste water plumbing system is fit for purpose when the next pandemic emerges.

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