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COVID-19: The environmental implications of shedding SARS-CoV-2 in human faeces

The ongoing COVID-19 pandemic is having significant public health repercussions, with a global response to limit the predicted mortality associated with this outbreak. The virus, 'severe acute respiratory syndrome coronavirus 2' (SARS-CoV-2), is a respiratory virus disseminated though droplets from coughs and sneezes from an infected person or from fomites (Hellewell et al., 2020). Therefore, many countries have put 'social distancing' measures in place to reduce person-to-person spread of the disease. However, recently it has been confirmed that infectious virions can also be present in human faeces (Ling et al., 2020), and there are reports that viral RNA can be persistently shed in faeces for a maximum of 33 days after the patient has tested negative for respiratory viral RNA (Wu et al 2020). Although it remains unclear whether SARS-CoV-2 can be transmitted via the faecal-oral route (Xu et al., 2020), viral shedding from the digestive system can last longer than shedding from the respiratory tract. As such, faecal-oral transmission may be an important, but as yet unquantified, pathway for increased exposure during the current outbreak (Wu et al., 2020). Therefore, safely managing faecal wastes from infected, recovering and recovered patients poses a significant nosocomial challenge. For example, during the SARS outbreak of 2002–2003, the closely related SARS-CoV-1 was detected in sewage discharged by two hospitals (Wang et al., 2005), which emphasises the care needed when handling such faecal wastes. However, these challenges are not limited to hospital wastes, as it has been predicted that most of the population will experience only mild symptoms of COVID 19 and convalesce at home, whilst others, including children, can carry the virus asymptomatically, and are still capable of shedding the virus in their faeces (Kam et al, 2020; Tang et al., 2020). This means that the virus could soon become widespread throughout wastewater systems (Naddeo and Liu, 2020). Whilst a lack of testing for the majority of the population makes it difficult to predict the spatially-distributed volume of potentially infectious faeces delivered through the sewerage infrastructure to wastewater treatment works (WWTWs), wastewater surveillance may be a useful tool to indicate where the virus is circulating in the human population (Lodder and de Roda Husman, 2020). However, whilst knowingly infected individuals can take steps to increase their level of hygiene, asymptomatic carriers do not change their behaviour, and can anonymously spread enteric pathogens within the community (Quilliam et al., 2013).

The public health implications of significant concentrations of SARS-CoV-2 arriving at WWTWs and the consequent discharge into the wider environment are only just beginning to be investigated (Lodder and de Roda Husman, 2020). Although current predictive models of human pathogenic virus fate and transfer from wastewater systems accommodate many sources of uncertainty, they will have limited use because unlike the enteric viruses (e.g. norovirus), the coronaviruses are covered by a lipid envelope (Schoeman and Fielding, 2019). This structural difference is likely to mean that they will behave differently in aqueous environments (Casanova et al., 2009). Coronaviruses can remain viable in sewage for up to 14 days (Wang et al., 2005) depending on the environmental conditions, e.g. temperature, and their association with biofilms. However, the presence of solvents and detergents in wastewater can compromise the viral envelope (Gundy et al., 2009). Although there is not yet any robust evidence for coronaviruses being directly transmitted by the faecal-oral route, the increase of viral load in the environment could increase potential human exposure. In particular, the transport of coronaviruses in water increases the potential for the virus to become aerosolised (Casanova et al., 2009), particularly during the pumping of wastewater through sewerage systems and at the WWTW, and during its discharge and subsequent transport through the catchment drainage network. Atmospheric loading of coronaviruses in water droplets from wastewater is poorly understood (Gundy et al., 2009), but could provide a more direct respiratory route for human exposure, particularly at sewage pumping stations, WWTWs, and near waterways that are receiving wastewater. Other situations where there is increased risk of human exposure from wastewater include high rainfall events which exceed sewerage and WWTW capacity, resulting in discharge from combined sewer overflows and sewer flooding (Ten Veldhuis et al., 2010). The risk of exposure via the faecal-oral route is also of particular concern in parts of the world where safely managed sanitation systems are limited, and particularly where there are high levels of open defecation or other forms of non-sewered sanitation (e.g. informal settlements or slums, and refugee camps). In these settings, it is common for waterways to be used as both open sewers and sources of water for domestic purposes, leading to the potential for continual dissemination of the virus through well understood faecal-oral routes (Quilliam et al., 2013). Such settings are commonly accompanied by poorly resourced and fragile healthcare systems, thus amplifying both exposure risk and potential mortality.

Currently, all published data on faecal shedding of SARS-CoV-2 come from hospitalised patients (e.g. Ling et al, 2020; Xu et al., 2020), with limited data on virus shedding in mild and asymptomatic cases (Tang et al., 2020). In the immediate future, there needs to be an investment of resources to improve our understanding of the risks associated with faecal transmission of SARS-CoV-2, and whether this respiratory virus can be disseminated by enteric transmission (Lodder and de Roda Husman, 2020). Although the mechanics of the interaction of this respiratory virus with the gastrointestinal tract remain relatively unknown, understanding the risk of spread via the faecal-oral route, while still at a fairly early stage of the pandemic, will allow more evidence-based information about viral transmission to be shared with the public. Furthermore, the risks associated with sewage loading during the remainder of the COVID-19 outbreak need to be rapidly quantified to allow wastewater managers to act quickly and put in place control measures to decrease human exposure to this potentially infectious material. Several strategies have been suggested to decrease viral loads in WWTWs, e.g. membrane bioreactors and emerging disinfection technologies (Naddeo and Liu, 2020). However, this would not

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necessarily provide protection to sewerage workers upstream of the WWTW, or populations affected by sewage flooding events. The current COVID-19 pandemic highlights how vulnerable we are to the risk of novel viruses being amplified by environmental drivers. At a time when the world is so focused on the respiratory pathways of a respiratory virus, understanding the opportunities for SARS-CoV-2 to be spread by the faecal-oral route must not be neglected.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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