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## Commentary

Ticking bomb: Prolonged faecal shedding of novel coronavirus (2019-nCoV) and environmental implications<sup>☆</sup>Olubukola Olayemi Olusola-Makinde<sup>a</sup>, Rine Christopher Reuben<sup>b, \*</sup><sup>a</sup> Department of Microbiology, Federal University of Technology, P.M.B. 704, Akure, Nigeria<sup>b</sup> Department of Science Laboratory Technology, Nasarawa State Polytechnic, Lafia, Nigeria

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## ABSTRACT

The current global coronavirus disease 2019 (COVID-19) pandemic caused by the severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) has been a tremendous public health challenge globally. While the respiratory transmission of SARS-CoV-2 has been established, evolving reports on the impact of the gastrointestinal system and the prolonged faecal shedding of SARS-CoV-2 show the likelihood of faecally mediated transmission. The increasing evidential presence of SARS-CoV-2 in wastewater and faecal material poses a significant public health threat which may potentiate global vulnerability to high risk of human exposure through environmental drivers especially in less developed countries. While extensively exploring the likelihood of faecally mediated SARS-CoV-2 transmission, infection control and prevention measures aimed at mitigating this pandemic should holistically include environmental drivers.

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## 1. Introduction

The current global coronavirus disease 2019 (COVID-19) pandemic caused by the novel coronavirus (2019-nCoV) or severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) has been a tremendous public health challenge globally, affecting over 7 million people in more than 200 countries of the world (WHO, 2020a; b). Due to the novelty of SARS-CoV-2, detailed pathogenesis and epidemiological dynamics of the novel virus remains poorly elucidated. So far, SARS-CoV-2 known to be a respiratory virus is primarily transmitted through respiratory droplets, mainly from coughs, secretions and sneezes of infected persons or from direct contact with infected persons or contaminated surfaces (Cai et al., 2020a; Hellewell et al., 2020; van Doremalen et al., 2020) with dry cough, fatigue, fever, breathing difficulty, pneumonia and diarrhoea as major clinical presentations (Jiehao et al., 2020; Wölfel et al., 2020; Zhang et al., 2020). Although respiratory complications and transmission of SARS-CoV-2 are well established, vertical, fomite-based and faecal-oral routes of transmission remain sparsely elucidated and ambivalent (Cai et al., 2020b; Chen et al., 2020a; Gu et al., 2020; Li et al., 2020; van Doremalen et al.,

2020). However, recently emerging and overwhelming reports on the involvement of the gastrointestinal system in the pathogenesis of SARS-CoV-2, the prolonged faecal shedding of SARS-CoV-2 in asymptomatic, convalescent and symptomatic patients (Gu et al., 2020; Xiao et al., 2020; Young et al., 2020; Zhang et al., 2020) and the isolation of viable SARS-CoV-2 from sewages (Medema et al., 2020; Ahmed et al., 2020) may support the rising likelihood of faecally mediated (faecal–aerosol/droplet, faecal–fomite or faecal–oral) SARS-CoV-2 transmission. With these evolving reports and evidence, the release of SARS-CoV-2 unto the environment is of eminent threat which may sooner than expected constitute a grave global public health challenge.

## 2. Presentation of concerns

Earlier documented studies conducted long before the emergence of SARS-CoV-2 have reported the faecal shedding of previously known coronaviruses (Xu et al., 2005; Dominguez et al., 2007; Drosten et al., 2013; Corman et al., 2016; Kim et al., 2016). The Middle East respiratory syndrome coronavirus (MERS-CoV) and the SARS-CoV which shares about 80% genetic similarity with SARS-CoV-2 were both detected in the faeces of some infected persons (Cheng et al., 2004; Xu et al., 2005; Drosten et al., 2013; Centers for Disease Control and Prevention, 2014; Wu et al., 2015; Corman et al., 2016) and hospital sewages (for up to 14 days) where

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\* Corresponding author.

E-mail address: [reubrine@yahoo.com](mailto:reubrine@yahoo.com) (R.C. Reuben).

patients were treated (Lee, 2003; Wang et al., 2005; Yeo et al., 2020). Whilst both MERS-CoV and SARS-CoV epidemics were of proportionate measure, affecting few territories, the disproportional global spread, severity and rapidly evolving dynamics of SARS-CoV-2 infection involving the environment should not be overlooked.

Recovered COVID-19 cases are usually asserted when discharge criteria are met. Presently in most developing countries, the discharge criteria include no relevant symptoms shown by the patient and a minimum of two consecutive negative test results by real-time RT-PCR of nasopharyngeal and sputum samples that were not retrieved 24 h (Wu et al., 2020). The negative test results mean that SARS-CoV-2 is no longer detectable in respiratory samples of infected persons. However, the prolonged detection of SARS-CoV-2 from faecal samples for 8, 9, 14 and 20 days even after the laboratory-confirmed absence of SARS-CoV-2 from respiratory samples as reported in China and elsewhere (Chen et al., 2020b; He et al., 2020; Ma et al., 2020; Wu et al., 2020; Xing et al., 2020; Xu et al., 2020) in relation with the criteria for the discharge of patients from health facilities is worrisome. Due to the overstretched and inadequate healthcare facilities in Nigeria as well as other developing countries, patients are often discharged once the respiratory samples test negative or when they become asymptomatic, usually about 20 days after the onset of initial symptoms. The Nigeria Centre for Disease Control (NCDC) has recently stated that "A negative laboratory test is no longer required to discharge a COVID-19 patient". Currently, symptomatic COVID-19 patients are discharged 10 days after the onset of symptoms in addition to 3 days of been asymptomatic (PM, 2020). Discharging patients who are actively shedding SARS-CoV-2 in their faeces will undoubtedly compound the woes of their communities and environment, hence increasing community transmission and environmental contamination.

Apart from the high possibility of the carriage and eventual transmission of SARS-CoV-2 by hospital wastes, surveys have predicted the manifestation of only mild COVID-19 symptoms which does not require hospitalization by a majority of the population while children amongst other populace may asymptotically harbor and shed SARS-CoV-2 in their faeces (Kam et al., 2020; Tang et al., 2020). The invariable faecal shedding of SARS-CoV-2 and the involvement of the environment depicts that sooner than ever expected, the novel virus could extensively spread throughout the environment especially the wastewater systems (Naddeo and Liu, 2020). With the inability of most countries to test the majority of their population, the surveillance and the circulation of SARS-CoV-2 in the human population and environment may be difficult to expatiate, predict and contain appropriately. Even so, individuals known to be infected with SARS-CoV-2 could deliberately improve their hygiene whereas those asymptotically carrying the virus without knowledge could take no measure and may become major anonymous sources for community spread.

The environmental and public health implications of the prolonged faecal shedding of SARS-CoV-2 with its attendant increasing concentrations directly on the environment or sewerage infrastructure to wastewater treatment works (WWTWs) are beginning to gain attention (Lodder and de Roda Husman, 2020). The increasing environmental concentrations of SARS-CoV-2 could further increase the risk of human exposure (Quilliam et al., 2020). Coronaviruses are known to increasingly become aerosolized when transported in water (Casanova et al., 2009) especially during the pumping and discharge of wastewater WWTWs (Quilliam et al., 2020). More so, the presence of atmospheric coronaviruses emanating from wastewater droplets (though not well elucidated) (Gundy et al., 2009) could significantly create an unswerving respiratory human transmission, particularly around WWTWs. In the

occasions of high rainfall or flooding which may lead to sewer overflows (Ten Veldhuis et al., 2010), the risk of human exposure to the virus increases.

Countries with inadequate sewage management systems, where people live in overcrowded slums, shanties and internally displaced or refugee camps characterized by different unhygienic kinds of non-sewered sanitation and open defecation are at high risk of faecally mediated and environmental exposure to SARS-CoV-2. It is a normal practice in these types of settings to use waterways for domestic purposes as well as open sewers. Also, human faecal materials openly deposited are often washed into waterways which are most times used for recreation, drinking and for household functions. These shabby practices could lead to continual virus dissemination which may result in an increased risk of exposure, morbidity and mortality. In situations where sanitation and hygienic practices are not efficient (as the case with developing/poor countries), prolonged faecal dissemination of SARS-CoV-2 from COVID-19 'recovered' patients or asymptomatic carriers may lead to the contamination of hospital wastewaters, domestic wastewaters, and all other associated links to water flow in the environment.

Even though the spread of SARS-CoV-2 through sewage aerosol is yet to be presently proven, the 2003 spread of SARS-CoV in the Amoy Gardens housing compound in Hong Kong was believed to be enhanced by aerosols from sewage (Hung, 2003). Contact with aerosols from sewage was disseminated by a poor drainage system in lavatory floor which permitted the development of virus enclosing droplets; these were possibly more dispersed by the aeration system provided in the apartment (Hung, 2003; Bell et al., 2004). Remarkably, the Amoy Gardens group was affected strangely by gastrointestinal symptoms, when compared to other SARS-CoV infected groups (Lee, 2003; WHO, 2003). Meanwhile, there are currently no pertinent statistics on viable virus load that would be needed for infection through water consumption.

Living and non-living environmental reservoirs accommodate infectious pathogens away from animal bodies. Environmental features, predominantly the water milieu and the technique of waste removal, are vital to the probable transmission of enteric pathogens-initiated infectious diseases (Prüss-Ustün et al., 2014) including COVID-19. SARS-CoV-2 is an enteric pathogen (Xiao et al., 2020). Most pathogenic enteric microbes are instantly infectious when excreted and culminate in water. The water milieu provides characteristic stability to pathogenic enteric microbes thereby making waterborne transmission an extremely effective route for spreading disease-causing microbes to the wide coverage of the populace. Most faecal-oral pathogens can be spread when susceptible individuals ingest or contact foods and water that are polluted with faeces. The sequelae arising from some water-associated infections are long-lasting (Aw, 2018). The dangers of infection are reliant on precise features of the pathogen such as potency, loads in excreta, their capacity to persevere in the environment and sewage treatment resistance. Pathogen loads specifically viruses and bacteria in sewage and faeces is high, classically at loads of millions to billions of such microbes (Aw, 2018). Generally, viruses persevere more in the environment and are more potent than vegetative bacteria. The consumption of/or exposure to very low dosages of the pathogenic viruses could result to the initiation of disease in humans.

If the transmissibility of SARS-CoV-2 through the faecal-oral route is proven, settings in laboratory and healthcare may provide an alternative potential target for forestalling additional disease blowout. The prolonged faecal shedding of SARS-CoV-2 necessitates the adherence of stern preventive procedures when handling faecal materials from infected persons (Yeo et al., 2020). The detection of SARS-CoV-2 in stool samples should be deliberated as a part of ideal diagnostic tests to initiate decision-making on the

discharge of COVID-19 recoveries from health facilities and isolation centers.

The increasingly evolving reports showing the involvement of the gastrointestinal system in SARS-CoV-2 pathogenesis and prolonged faecal shedding of the novel virus shows yet a massively potential global vulnerability to the risk of human exposure through environmental drivers. Increased attention should be given to the lung-gut axis while extensively exploring the likelihood of faecally mediated SARS-CoV-2 spread.

### 3. Conclusions

With the established presence and prolonged faecal shedding of SARS-CoV-2, control measures for waterborne transmission are pertinent. This could involve the treatment of water and source guard to advance microbial water quality. Immediate actions are expected on satisfactory water chlorination, this is presently assumed to be enough cure for the virus inactivation (Centers for Disease Control and Prevention, 2020). Strict and standard precautions in processing hospital wastewater which may minimize contact with aerosols generated from sewage should be enforced. However, it is disheartening to note that developing countries have grossly inefficient wastewater treatment, and attaining water safety in those countries during this pandemic is a mirage. Furthermore, attention should be drawn to safe stool disposal of recovered infants and young children. Stools and stool sample containers should be safely discarded into special disinfectant-filled containers (such as buckets), plastic disposal boxes, or hazardous waste bags. More prolonged shedding of SARS-CoV-2 has been recorded in children (Ma et al., 2020; Xing et al., 2020). COVID-19 could be effectively contained if holistic infection control and prevention measures environmental drivers are considered.

### 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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Authors have over the years worked on emerging and re-emerging zoonotic viral pathogens including Lassa, Ebola, rabies etc. They are trained public health and environmental microbiologists as well as serving faculty members.

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