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Wastewater surveillance for Covid-19: An African perspective

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HIGHLIGHTS

- Wastewater surveillance could play a key role in management of the COVID-19 pandemic.
- Unlike well-resourced countries, there is high reliance on non-sewered sanitation systems in resource-constrained regions.
- In sub-Saharan Africa, locally relevant alternatives to sampling from wastewater treatment plants are required.

GRAPHICAL ABSTRACT

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ABSTRACT

The COVID-19 pandemic has once again highlighted the importance of access to sufficient quantities of safe water and sanitation in public health. In the current COVID-19 pandemic, an early warning wastewater system has been proposed as a platform for SARS-CoV-2 surveillance, and a potentially important public health strategy to combat the disease. This short communication on wastewater surveillance in sub-Saharan Africa highlights challenges, opportunities and alternatives taken into account the local context.

The COVID-19 pandemic has once again highlighted the importance of access to sufficient quantities of safe water, and sanitation in public health. Well managed water, sanitation and hygiene (WASH) are critical for protection of human health during disease outbreaks (World Bank, 2020). Wastewater contains viruses, bacteria and parasites and inadequate treatment of, or exposure to, wastewater and fecal sludge plays a role in spreading disease (Carr et al., 2004; UN, 2020). On the other hand, tracking of wastewater has historically played a key role in the development of early warning systems (EWS) for various enteric viruses, including poliovirus, norovirus and hepatitis (Hovi et al., 2012; Smith et al., 2016; Tiwari and Dhole, 2018). In 2011, Kano State of Nigeria was the first on the African continent to introduce environmental surveillance for poliovirus and many other regions in Africa have since included wastewater surveillance to supplement polio eradication

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efforts (Gumede et al., 2018; Weldegebriel et al., 2015; Eboh et al., 2018). To date, the screening of wastewater is recognized as an important tool for monitoring wild poliovirus and vaccine-derived polioviruses (Gumede et al., 2018; World Health Organization, 2003).

In the current COVID-19 pandemic, tracking of wastewater has been proposed as a platform for SARS-CoV-2 surveillance, and a potentially important public health strategy to combat the disease (Mao et al., 2020a; Sharif et al., 2020). Diarrhea is a frequent presenting symptom in patients with COVID-19, and SARS-CoV-2 RNA has been detected in stool samples from both adults and children (Ahmed et al., 2020; D'Amico et al., 2020; Kitajima et al., 2020; Xu et al., 2020). Thus SARS-CoV-2 surveillance through water-based epidemiology (WBE) is a potential complimentary and cost-effective approach to enable wide scale screening which would reduce labor intensive and costly personal COVID-19 testing and tracings (Mao et al., 2020a; Brouwer et al., 2018; Hart and Halden, 2020). To date, the detection of SARS-CoV-2 RNA has been demonstrated in the wastewater of a growing number of countries including Australia, France, the Netherlands and the United States of America (Ahmed et al., 2020; Lodder and de Roda Husman, 2020; Medema et al., 2020; Wu et al., 2020; Wurtzer et al., 2020). Notably most of this work has been carried out in high-income countries.

Like most epidemics, the rapid spread of COVID-19 is likely to disproportionately affect the most disadvantaged and vulnerable communities (Hart and Halden, 2020; Kinner et al., 2020; Health, T.L.P, 2020). Currently COVID-19 prevalence is influenced by regions supporting high frequency screening and testing, compared with poorly resourced regions where low prevalence may be linked to underreporting (Hart and Halden, 2020; Kavanagh et al., 2020). Therefore, wastewater surveillance systems may prove critical in many low- and middle-income countries where health systems infrastructure, testing systems, personal protective equipment (PPE) and human resource capacity are constrained (Kavanagh et al., 2020; Martinez-Alvarez et al., 2020). Nonetheless, the proposed opportunities presented by wastewater surveillance need to be understood in the local context which will in turn give rise to locally relevant, evidence-informed solutions.

In 2017, among the 2 billion people worldwide still without basic sanitation coverage, 35% (709 million) lived in sub-Saharan Africa (World Health Organization, 2019). Unlike well-resourced countries, there is a high reliance on non-sewered sanitation systems across the region. Mostly evident in rural areas, the ten countries with the highest levels of open defecation are all in sub-Saharan Africa (World Health Organization, 2019). Approximately one in five people in Africa practice open defecation which, from a public health perspective, may contribute to the spread of disease (Hickling, 2013; Saleem et al., 2019).

By 2030, the sustainable development goal (SDG) 6 aims to achieve access to adequate and equitable sanitation and hygiene for all and eliminate open defecation (WHO, 2014). In South Africa, which has one of the biggest economies in Africa, albeit also having one of the highest inequality rates, approximately 37% of households are not connected to a water-borne sewage system, and instead rely on alternatives such as pit latrines, bucket toilets and chemical toilets (StatsSA, 2017). The low level of connection to wastewater treatment plants will have to be considered when designing an EWS and alternatives will need to be found for those not connected to the sewage network. For example, the possible release of raw sewage into the water course calls for the investigation into contaminated surface waters which may provide relevant information on distribution and persistence of enteroviruses, including SARS CoV-2, circulating in a particular community (Apostol et al., 2012; Hamza et al., 2009).

Globally, sub-Saharan Africa has the highest proportion of the population sharing toilets (Rheinländer et al., 2015; WHO/UNICEF Joint Water Supply Sanitation Monitoring Programme, 2014). In densely populated urban areas, communal or shared toilets are common (Morella et al., 2008).

A study of 100 households in a low-income urban settlement of Nakuru, Kenya revealed that all pit latrines were shared by more than one family, and the average number of people sharing a pit latrine was 23 individuals (ranging between 4 and 56) (Gudda et al., 2018). To date, no cases of transmission via the fecal–oral or waterborne routes have been reported for SARS-CoV-2, and it has been suggested that infection via this route is improbable during quarantine or while under self-isolation (Wu et al., 2020; Amirian, 2020). However, this may not be the case for shared spaces and potential fecal–oral transmission might pose an increased risk in contained living premises such as hostels and similar places of overcrowding (Wu et al., 2020). The sampling of non-sewered systems such as pit latrines has been proposed as a potentially important tool for community health surveillance in low resource settings (LaHue and Alexander, 2018), which needs to be investigated for SARS CoV-2.

Africa has the highest rate of population growth and the population is estimated to double by 2050 (UN, 2019). This will cause an added strain in providing services for basic sanitation. Fecal coliform concentration is strongly associated with upstream population density (Milledge et al., 2018; UN Water, 2015) therefore the ability to detect SARS-CoV-2 RNA in wastewater treatment plants that service areas with high population density needs to be determined.

In regions connected to the wastewater system, the type of sewage network (e.g. separate or combined) may influence the ability to detect SARS-CoV-2. In many cases the operation and maintenance of the separate systems, whereby separate pipes are used to transport the surface run-off and the sewage, are not well managed (UN Water, 2015). Furthermore, wastewater systems may have large numbers of unlawful connections such as illegal discharge into stormwater drains (UN Water, 2015; Levin et al., 2020). Little is known about the impact of dysfunctional sewer systems, as have been reported throughout Africa, on capacity to detect SARS-CoV-2 RNA in wastewater. Extreme weather events such as floods can damage or destroy wastewater treatment systems and cause overflow of untreated sewage (WHO, 2019). Moreover, the rainy season is associated with the increase in the overflowing of pit latrines (Nakagiri et al., 2016; Sengupta et al., 2018). Owing to the impacts of climate change, sub-Saharan Africa has been identified as a vulnerable region with emphasis on weather-related extremes such as floods (Carabine et al., 2014). This will further compound increasingly overburdened wastewater systems. Season change and differing climate regions have pronounced effects on wastewater surveillance and may affect the persistence of SARS-CoV-2 in wastewater (Hart and Halden, 2020). According to Hart and Halden (Hart and Halden, 2020) temperature effects may affect virus detectability and if such factors are not taken into account, wastewater temperature may lead to under or over estimating COVID-19 prevalence and thereby misinform the public health response. This is a key consideration when planning a national wastewater surveillance in expansive countries like Algeria, Nigeria and South Africa which have national climatic diversity. However, if properly used, the EWS could detect COVID-19 hotspots brought on by such extreme climate events (Kitajima et al., 2020).

The complexity of testing wastewater as a surveillance tool, including specific challenges related to SARS-CoV-2 wastewater testing, have been well described (Mao et al., 2020a; Kitajima et al., 2020; La Rosa et al., 2020). A study in 2013 revealed that of the 49 sub-Saharan Africa countries, 37 (76%) had no clinical laboratory accredited to international standards (Schroeder and Amukele, 2014). Wastewater testing requires expensive equipment and skilled laboratory staff to manage the complicated sample handling and processing (World Health Organization, 2003; Mao et al., 2020a). As the reproducibility of wastewater sampling to guide public health interventions is crucial, intra- and inter-laboratory comparison is important for quality control (Ahmed et al., 2020); however lack of laboratory coverage may limit this important quality aspect aligned with Good Laboratory Practice. Current work is underway to develop small, portable paper-based wastewater testing devices that aim to reduce the above-mentioned issues, including possible lack of power supply (Mao et al., 2020b) which may be well suited for low resource settings. It is noteworthy that a few patient-centered rapid immunodiagnostic tests are currently available but only in higher income settings (Kavanagh et al., 2020).

In conclusion, the burden of poor sanitation falls disproportionately on the poor who require urgent and innovative COVID-19 responses within complex circumstances. The viability and infectivity of SARS-CoV-2 in feces needs urgent investigation in high risk settings (Wu et al., 2020; Yuen et al., 2020), particularly for those communities practicing open defecation and those using unimproved sanitation facilities. Wastewater surveillance of SARS-CoV-2 has the potential to be a powerful public health tool in Africa, however alternatives to sampling from wastewater treatment plants need to be supported by solutions for more locally relevant situations taking sanitation diversity into consideration.

CRediT authorship contribution statement

Renée Street: Conceptualization, Writing - original draft, Writing - review & editing. **Shirley Malema:** Conceptualization, Investigation, Writing - original draft, Writing - review & editing. **Nomfundo Mahlangeni:** Investigation, Writing - original draft, Writing - review & editing. **Angela Mathee:** Conceptualization, Writing - original draft, Writing - review & editing.

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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