

Commentary

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# Considerations for conducting wastewater-based public health assessments in migrant populations

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## Abstract

Wastewater-based epidemiology (WBE) provides the ability to generate inclusive and comprehensive population-level health assessments of communities. Recent work suggests these inherent benefits of WBE can serve to support vulnerable communities worldwide, such as migrant populations. The topic of forced migration has gained significant attention in recent decades as conflict and climate change events have increasingly become major drivers of migration around the world. However, information on the health of displaced populations during times of active mobility is lacking due to several logistical and ethical challenges using conventional methods. As environmental, political, and humanitarian conditions continue to evolve, it appears necessary to pursue alternative and adaptable approaches to acquire the health status of such dynamic and vulnerable populations. Here, we propose a call to action to apply WBE in migrant populations to offer inclusive and minimally invasive health assessments in order to: (1) close data gaps in the health information of displaced populations actively traveling along migratory pathways; and (2) promote greater efficacy in deployed interventions. Suggestions to pursue urgent migrant-specific health priorities are proposed, including antimicrobial resistance (AMR), infectious diseases, and malnutrition, along with considerations to promote ethically sound investigation. Overall, these recommendations may serve as a foundation to support subsequent investigation, with the purpose of encouraging global collaboration to offer new insights into the health of migrant and/or forcibly displaced populations.

**Keywords:** Wastewater-based epidemiology (WBE), public health, migration, forced displacement, antimicrobial resistance, infectious diseases, environmental exposures, underserved populations



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## INTRODUCTION

Forced migration has gained widespread attention in recent decades, notably in 2015, when millions of refugees began to surge throughout the European Union, establishing what is now widely referred to as the “migration crisis”<sup>[1]</sup>. As of 2020, the total number of migrants globally was estimated to be over 280 million, largely traveling via four major routes: Eastern Mediterranean, Mediterranean Sea, Central American, and Southeast Asian, which branch off into multiple sub-pathways across vast regions<sup>[2]</sup>. In addition to threats of violence and unpredictable climate conditions during times of active mobility, these communities are often subject to diminished access to healthcare and essential resources, increasing vulnerability to disease (e.g., communicable, non-communicable, diarrheal), food insecurity, exposure to toxic environmental contaminants from temporary shelters, and mental health conditions such as depression, anxiety, and post-traumatic stress disorder (PTSD)<sup>[2]</sup>. A recent report by the World Health Organization (WHO) concluded there are significant gaps in transferable knowledge with regard to migrant health that exist in the current literature<sup>[3]</sup>. Despite this, it has been determined that the experience of migration alone is considered a key determinant of health, and collective action is needed in order to create more adaptable healthcare systems that can be tailored to their unique needs<sup>[3]</sup>. However, challenges exist that hinder our understanding of what those needs are, including obtaining approvals and informed consent to interact directly with migrants for interviews, surveys, or sample collection (blood, urine, stool), working in potentially dangerous settings with limited resources, and concerns of misinterpretation or misclassification of results that would put individuals at risk of deportation<sup>[4,5]</sup>. These limitations may offer an explanation as to why most studies to date report on the health parameters of migrants either in their originating or destination endpoints, negating the in-between<sup>[6,7]</sup>. This gap in knowledge suggests that current estimates of incidence, prevalence, and circulation of certain diseases and conditions within migrant populations across the world may be a significant underrepresentation, and thus warrant the need for alternative approaches that can provide this information while simultaneously protecting individual autonomy and integrity<sup>[8]</sup>.

Wastewater-based epidemiology (WBE) may be well positioned as a solution in this context as it is a powerful tool capable of generating inclusive, minimally invasive, and anonymous population-level health assessments through the analysis of biomarkers derived from composited human excreta (i.e., urine, feces) that presents in community wastewater<sup>[9,10]</sup>. This methodology has been widely adopted in recent years for implementation of national and international SARS-CoV-2 monitoring in support of public health decision-making during the COVID-19 global pandemic, which demonstrated its ability to provide an early warning signal of community viral presence, as well as identify hotspots of infection in areas that may have otherwise been missed using conventional methods<sup>[11,12]</sup>. Overall, this historical and continued success has encouraged a recent interest in the application of WBE in vulnerable populations to reduce global health disparities, with migrant populations often identified as the most vulnerable<sup>[13,14]</sup>. For example, in refugee camps worldwide during the COVID-19 pandemic, the United Nations High Commissioner for Refugees (UNHCR) reported in late September of 2020 that of the > 30 million refugees at the time, only 21,000 tested positive across 97 countries<sup>[15]</sup>. While positivity rates continued to increase in the following weeks, officials warned that these reports were vastly underestimated, likely due to limited testing efforts. Additionally, half of refugees worldwide are under the age of 18, rendering this large subsection of the population more resilient to severe infection and/or asymptomatic, and therefore may be less likely to seek testing, if available<sup>[16]</sup>. Intervention efforts to reduce community spread, such as social distancing and handwashing, were far more challenging to implement due to limited information on viral transmission, lack of resources such as clean water, and significant overcrowding in refugee camps<sup>[17,18]</sup>. Once available, vaccine distribution efforts in migrant communities also proved to be challenging. In late August of 2021, it was reported that over 57% of populations in high-income countries were vaccinated, compared to only 2% of low-income countries, with lack of vaccine supplies and financial means to support equitable rollout constituting as

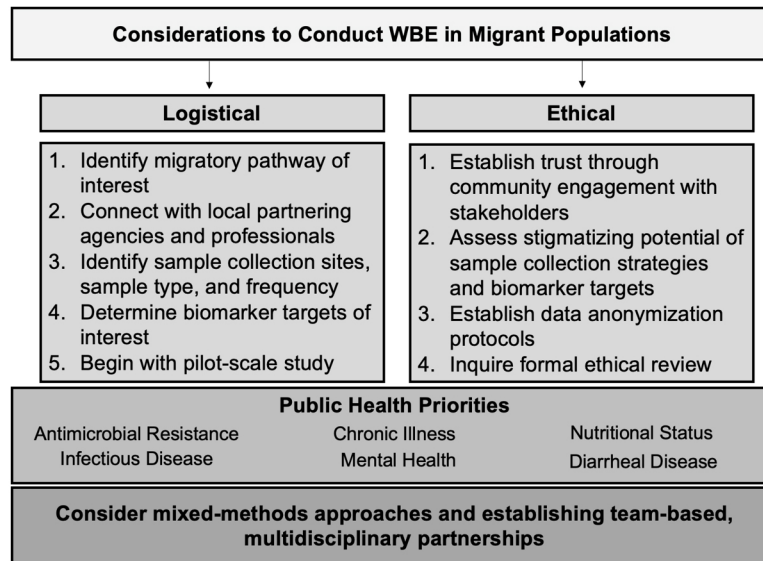
major drivers behind this difference. Over 86% of migrant populations reside in low-income countries, leaving these communities at far greater risk of infection or re-infection during that lag period<sup>[19]</sup>.

While WBE may not directly contribute to improving the availability of resources, it has been proven to enhance the decision-making process for how existing resources can be effectively and efficiently allocated in near real-time by informing on viral presence in the absence of a formal clinical infrastructure regardless of whether contributing individuals are exhibiting symptoms. This was demonstrated early in the pandemic when the use of WBE identified hotspots of infection and offered an early warning signal of viral presence weeks in advance for COVID-19-related hospitalizations, deaths, and clinical cases, owing to the reality that local clinical testing took up to six months to perform at a comparable capacity to WBE<sup>[20]</sup>. In such low-resource settings, time and information are extremely valuable. If an established WBE program were present along a migratory route at the time of the COVID-19 pandemic, increased detection of viral presence in one camp may have prompted a response to inform neighboring camps in order to proactively prepare for a potential outbreak by efficiently reallocating resources and implementing appropriate interventions early that would not come at the expense of other crucial healthcare initiatives in these communities, such as maternal and child health services and routine childhood immunizations<sup>[21]</sup>. Thus, it appears appropriate and necessary to apply WBE along migratory pathways in order to provide a foundational set of knowledge on the overall current health status during times of active transport, serving to close these significant gaps in data and promote the integration of proactive data-driven interventions.

## A PROPOSED FRAMEWORK TO IMPLEMENT WBE IN MIGRANT POPULATIONS

At its core, the purpose of conducting WBE is to ultimately support public health strategies across a diverse set of disciplines to promote a comprehensive assessment of human health. This has been applied in a number of contexts that broadly assess human behavior, exposure, and activity, specifically for substance use patterns, dietary behaviors, environmental exposures, and infectious disease monitoring, conducted in a variety of settings (e.g., rural, urban), geospatial scales (e.g., building, campus, neighborhood, city), and sample collection strategies (e.g., type of sample, frequency, and study duration)<sup>[22-24]</sup>. These successful reports all solidify WBE's ability to fluidly adapt to a given public health priority according to community needs and resource availability. Thus, building on this prior work, a generalized framework is proposed herein to guide the decision-making process when considering conducting WBE in migrant populations [Figure 1].

First, it is essential to identify a specific migratory pathway of interest, which will ultimately serve to create an overall roadmap for the entire WBE program given the current political landscape, climate conditions, community need, available infrastructure, or any other potential barrier to accessing the community. For example, the Western Balkans Route is one of the most active migratory pathways into the European Union that typically involves transit through Albania, Bosnia and Herzegovina, Montenegro, North Macedonia, and Serbia from originating areas throughout the Middle East, Asia, and Africa. Changes in border management strategies and policies place continuous strain on populations in transit, thus impacting overall migratory flows; it would be critical to assess and understand these changes prior to choosing a particular site and/or region to conduct WBE<sup>[25]</sup>. Second, identifying and connecting with relevant local or international organizations and/or agencies who work directly with the migrant populations is crucial for obtaining approvals to access the determined sites. Specific partnering agencies that may fit these criteria depending on geographic location may include: the United Nations High Commissioner for Refugees (UNHCR), the International Organization for Migration (IOM), Danish Refugee Council (DRC), and the International Rescue Committee (IRC). When forming these partnerships, it is essential to ensure all participating members are aligned on the main objectives of the program in order to prevent potential



**Figure 1.** Proposed framework with logistical and ethical considerations as well as public health priorities and methodological approaches for conducting wastewater-based epidemiology (WBE) in migrant populations.

retaliation, such as increased risk of deportation. Establishing partnerships with professionals within the surrounding residential community, such as physicians, pharmacists, nonprofit organizations, and academic institutions, will also be beneficial as these individuals or groups could offer deeper contextual insight that would complement the ultimate measured results from WBE. Third, sample collection sites will need to be identified, which will vary greatly depending on resource availability and existing infrastructure. In cases where refugee camps are connected to the host region's sewer network, partnering with the local public works or sanitation and utilities department may serve to facilitate granted access to the collection of community sewage and inform where samples may be collected from, such as a nearby maintenance hole (e.g., manhole) that receives direct effluent from the camp and has minimal tie-in from an adjacent community. In other camp locations that are not connected to the sewer infrastructure, facilities may be installed temporarily on site (e.g., pit latrines), which could be directly sampled from and would offer a composited yet isolated signal of the inhabitants of the community<sup>[26]</sup>. Sample collection from building cleanouts may also be an option from shared communal areas (i.e., dining halls, recreational buildings, etc.); however, this may require additional approvals in an effort to preserve privacy<sup>[27]</sup>. Finally, in circumstances where facilities and resources are extremely limited due to the tremendous influx of refugees and/or asylum seekers, such as the case in Cox's Bazaar in Bangladesh, sampling from a nearby water body may suffice<sup>[28]</sup>. Universally, regardless of the setting, choice of the type of sample collected (grab, 24-hour composite, passive), as well as frequency (daily, weekly, monthly) and geospatial resolution, is often highly dependent on the existing built environment, for example, if an access point is obstructive to traffic patterns or poses a potential physical danger to the sample collector then it may not be suitable for frequent and/or long-term active sample collection. In this case, passive sampling methods may be a viable and low-cost option that has been demonstrated to provide valuable information, particularly when assessing the absence or presence of potentially harmful biological or chemical threats; however, it is important to note that the use of passive sampling decreases the ability to produce quantitative data due to limitations such as absorbent saturation and loss of temporal variation<sup>[29]</sup>. This becomes more relevant when applying this in the context of migrant communities, considering the dynamic nature of movement and the average length of stay at a given camp. For instance, the amount of time a migrant or migratory unit (i.e., family) may stay at any given location is highly variable, ranging from days to decades, and is dependent on a multitude of factors, including

availability of resources, location, existing medical conditions, or conflict<sup>[30]</sup>. Understanding the current situation can help formulate an appropriate sample collection strategy for the WBE program. Fourth, not unlike other WBE studies, the target(s) (i.e., biomarkers) of interest measured in wastewater that indicate various aspects of health are also important to consider when initiating protocols. For instance, sample collection frequency and spatial requirements for measuring trends of biomarkers indicative of chronic illness often differ from that of infectious diseases, and even more so for applications that involve aspects of human behavior (e.g., food consumption, substance use). Overall, it is recommended to begin with a pilot-scale study that may focus efforts on a small number of sites in order to establish competency and promote sustainable and scalable expansion after successful implementation. Further, it is important to consider the stigmatizing potential of certain biomarkers (i.e., indicators of substance use) measured in wastewater that could lead to retaliation if not carefully reviewed prior to program commencement. Thus, including potential ethical pitfalls in this framework is essential to minimize harm to these already vulnerable populations.

## ETHICAL CONSIDERATIONS

Historically, research and institutional ethics committees often exclude oversight for WBE-related investigation as it typically does not involve intervening with individual human subjects, and therefore, there is currently no established ethical framework. This absence of ethical standards has prompted recent efforts by experts within the field to curate ethical criteria for WBE, especially in vulnerable populations<sup>[31-33]</sup>. Of these, major emphasis is placed on community engagement prior to the start of the study in order to establish trust and learn the interests of the participating entities. This poses a unique challenge when working in migrant communities, given their inherently dynamic nature; however, as mentioned above, it may still be accomplished by partnering with local public and nonprofit organizations that work directly with migrants and whose main objective is to support the overall health and well-being of the community. These organizations could thus offer invaluable insight into what the specific needs may be, how the use of WBE could benefit the community, and provide guidance in order to meet those needs. These partnerships are essential to ensure the program is successful and sustainable through established and engaged community support.

A commonly reported benefit of using WBE is the anonymous nature of collecting a composited wastewater sample, thereby significantly reducing the ability to identify any single human being based on the measured biomarker. While this is true, it is imperative to consider how this may apply in the context of migration, for example, when sampling from a reception center with a potentially low population size (< 1,000). Considering geospatial granularity and proximity for sample collection (i.e., how close to the community should samples be collected) and establishing a working group of all participating agencies where detailed responsibilities and protocols for data collection, reporting, and interpretation are established, are all essential activities in order to ensure anonymity and minimize the potential for stigmatization or retaliation. While this may vary for each community, it is strongly encouraged to discuss the community's preference for sample collection strategies (i.e., sample collection site, catchment population size, *etc.*) so the needs and comfort levels are met by the WBE program. While it is acknowledged that full anonymization may not be possible given the isolated nature of these communities, displaying data as a population rate (i.e., per 1,000 or 10,000 people), with the intent to mitigate potential retaliatory impacts and preserve individual autonomy (i.e., stigmatization) is strongly recommended as best practice in migrant populations<sup>[34]</sup>. Furthermore, to protect potential future misuse of samples, it is encouraged to discard leftover samples not used for analysis rather than archiving, unless a specific use has already been identified and documented. Overall, anticipating potential data-triggered actions that may arise from WBE investigation by submitting for formal ethical review regardless of intent is suggested here as best practice, especially in such vulnerable

populations. Establishing multidisciplinary, team-based partnerships with several levels and areas of expertise thoroughly represented, including bioethicists, engineers, public health officials, and social scientists, is necessary.

## **A CALL TO ACTION: FUTURE APPLICATION TO ADDRESS PERTINENT PUBLIC HEALTH PRIORITIES**

As mentioned, migrant populations are often subject to challenging conditions during times of active mobility with diminished access to essential resources and healthcare, which heightens their vulnerability to adverse health outcomes. The World Health Organization recognizes these circumstances, and has identified displacement and migration as key determinants of health, highlighting specific public health areas that warrant prioritization for investigation using WBE, such as: antimicrobial resistance (e.g., antibiotic misuse/overuse), diarrheal and/or infectious diseases (e.g., cholera, COVID-19, influenza), chronic illness (e.g., environmental exposures, diabetes, cancer), mental health (e.g., depression, anxiety), and nutritional status (e.g., food insecurity, undernourishment)<sup>[3,8]</sup>. Encouraging the adoption of mixed-method approaches, which involve the analysis of quantitative WBE data on biomarkers in conjunction with qualitative reports (e.g., interviews, surveys) from local organizations, health professionals (e.g., physicians, pharmacists), or other foundations that work with the migrant population, will enable a deeper understanding of the public health application under investigation. An example of this may involve identifying and measuring indicators of antimicrobial resistance in wastewater. This is achieved through the use of sequence-based or gene expression techniques that target antibiotic resistance genes (ARGs). Concurrently, interviews are conducted with local pharmacists or physicians, either in the surrounding residential community or within the reception center's infirmary, aiming to gather information about prescription protocols for antibiotics (e.g., brands, types, frequency, rationale). This will provide a comprehensive understanding of the current issue, offering differential insights into the resultant quantitative measurement in wastewater, and prompt further engagement to inform appropriate intervention strategies, all while keeping in mind potential ethical pitfalls for data anonymization and reporting.

It has been proven that wastewater-based epidemiology can offer the ability to provide rapid, inclusive, anonymous, and minimally invasive health information on communities across the globe for a wide variety of public health applications. Given the distinctive circumstances that migrant populations endure during active mobility, where resources are severely limited and basic conditions are unstable, the recommendations discussed herein recognize the substantial benefits that WBE can provide in order to extend support for these populations. Consequently, it not only appears logical and practical but also assumes the role of an ethical and moral obligation, compelling us to take action and expand this research solely for this purpose. This endeavor offers a blueprint for future global health applications and contributes novel insights and information regarding migrant communities.

## **DECLARATIONS**

### **Author Contributions**

Conception, investigation, writing/editing of the original manuscript draft: Bowes DA

Writing/editing of the revised manuscript draft, oversight: Zaman MH

### **Availability of Data and Materials**

Not applicable.

## Financial Support and Sponsorship

None.

## Conflicts of Interest

All authors declared that there are no conflicts of interest.

## Ethical Approval and Consent to Participate

Not applicable.

## Consent for Publication

Not applicable.

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