

FROM SENSING TO MAKING SENSE

Genomic Wastewater Surveillance For Infectious Disease Monitoring

Helen Phipps Booz Allen Hamilton Alexandria Tepper Booz Allen Hamilton Daniel Edwards Booz Allen Hamilton Ravi Shankar Booz Allen Hamilton Michelle Schmitz Booz Allen Hamilton Kris Rathinam Booz Allen Hamilton Kevin Berry Booz Allen Hamilton Kate Horne Booz Allen Hamilton Erin McAuley Booz Allen Hamilton

Genomics-based wastewater surveillance for detecting infectious human pathogens has been used for over a decade and recently widely implemented for SARS-CoV-2 surveillance. Numerous enteric and non-enteric human pathogens, some which may be used as biothreat agents, can be detected in wastewater. Studies have correlated pathogen detection with prevalence of human disease in the corresponding population, identified novel variants, and detected pathogens in wastewater before the identification of clinical cases in the community—providing early warning.

The objective of this study was to examine the extent to which genomics-based wastewater surveillance systems (WSS) are used to detect the presence of human pathogens to include biothreat agents. This study also aims to assess the effectiveness of current genomics-based WSSs to enable advanced prediction of disease and to inform medical and operational decisions such as countermeasure deployment and biodefense actions.

A review of the peer reviewed literature was conducted to identify publicly available studies describing genomics-based WSSs to assess the presence/severity of select viruses relevant to U.S. military and associated populations. Studies included surveillance of general populations or those targeted to congregate settings via collection of raw sewage/influent, primary effluent, and/or secondary effluent. Data collected for each WSS included the pathogen(s) assessed, source of the wastewater, sample collection method, pathogen detection method, and mechanism(s) for prediction for early warning.

There has been a substantial increase in publications describing WSSs for detection of pathogens since 2020, driven by the goal of detecting SARS-CoV-2. The initial findings are from articles published between 2010 - 2022. The pathogen types include 65% (11) non-enveloped enteric viruses, primarily norovirus, astrovirus, rotavirus, adenovirus, and Hepatitis A; and 35% (6) SARS-CoV-2 studies. The wastewater sample collection methods varied across studies. Composite sampling was used in 57% of the enteric studies and 43% of SARS-CoV-2 studies. Grab sampling was used in 71% of the enteric studies and 29% of SARS-CoV-2 studies. Sampling locations included sewage influent, effluent/discharge, and other pumping stations. Timelines from sample collection to detection/severity prediction were inconsistently reported. Studies that reported the timeliness ranged from detection 2 weeks to 18 months before confirmation of clinical cases in the community. Many studies failed to assess correlation of the presence of pathogen genetic material in wastewater samples with prevalence and/or timing of clinical cases in the community.

These studies serve as a proof-of-concept for development and implementation of WSSs for pathogen shedding of biothreat agents in sewage. Identifying and mitigating shortfalls in current methodologies/practices concurrent with adopting innovations can significantly improve routine surveillance before clinical symptoms. However, more studies are needed with consistent reporting of timeliness of detection, severity, and correlation with clinical presentation.

Early identification of militarily relevant pathogens in garrison, training, and operational environments will facilitate actions to limit widespread transmission and therefore mitigate adverse effects to warfighter health and mission capabilities. Innovations in sample collection and processing methodologies, data management and analysis, and other downstream steps can be applied to biothreat agent detection and monitoring to bolster health service support, force health protection, and risk management activities.

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