Environmental SARS-CoV-2 and COVID-19 prediction at local, regional and national scales

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ABSTRACT

BACKGROUND. Humans (and animals) shed pathogens through their bodily fluids, exhalation and touching objects/surfaces. Thus, their genomic footprints can be traced in the air, on surfaces and in wastewater samples. We quantify acute respiratory syndrome coronavirus 2 (SARS-CoV-2) concentrations in environmental samples and their associations with COVID-19 cases at multiple scales (building, campus, and county levels). We hypothesize that SARS-CoV-2 can be detected in environmental samples several days prior to clinical detection of COVID-19 cases.

METHODS AND MATERIALS. At the building level, daily samples of air, surface (swab) and wastewater were collected from March 2 to May 21, 2021. At the campus level, weekly wastewater samples were collected between September 2020 to July 2021. For both building and campus scales COVID-19 data were acquired from the University of Miami (UM). RNA extracted from these samples was analyzed at UM for SARS-CoV-2 nucleocapsid gene using qPCR. At the county (level, wastewater data were acquired from 30 counties from BioBot and COVID-19 data from CDC's National Environmental Public Health Tracking Network (NEPHTN), respectively. The association between location-specific COVID-19 cases and time-lagged genomic copies (GC) of SARS-CoV-2 in the environmental samples was examined using descriptive analyses and hierarchical regressions.

RESULTS. SARS-CoV-2 was detected in 47%, 31.8% and 51.8% of the 83 samples of each air, surface (swab) and wastewater, respectively. Positive COVID-19 cases were detected on 11 of the 44 days of students' screening during the study period, and SARS-CoV-2 was detected 100%, 80% and 91% of the times in the air, on high touch surfaces and in wastewater samples, respectively, within 3 days prior to the detection of these cases. UM campus-wide data show that SARS-CoV-2 concentrations in weekly wastewater samples was significantly lower in Fall 2020 than in Spring 2021; there was a 48% higher chance of COVID-19 case detection with 1% or a unit increase in $\log_e$(GC SARS-CoV-2 copies/L) four days prior to the clinical diagnosis of cases (odds ratio = 1.48; 95% CI = 1.01 to 2.19; $p < 0.05$). For the county analysis, a 1% increase in the 3-week rolling average of SARS-CoV-2 was associated with a 0.58% increase in the 3-day moving average of COVID-19 positivity rate (coefficient = 0.58; 95% CI = 0.48 – 068; $p < 0.01$). This association varied across counties, and it was stronger for Miami-Dade (coefficient = 0.80; 95% CI = 0.63 – 0.98; $p < 0.01$) than for the association at the national level.

CONCLUSION. Environmental SARS-CoV-2 peaked 3-4 days prior to the clinical detection of COVID-19 cases. Thus, a proactive environmental monitoring in public places of diseases causing pathogens can potentially guide infectious disease mitigation strategies.