SARS-CoV-2 RNA concentrations in primary municipal sewage sludge as a leading indicator of COVID-19 outbreak dynamics Jordan Peccia, Alessandro Zulli, Doug E. Brackney, Nathan D. Grubaugh, Edward H. Kaplan, Arnau Casanovas-Massana, Albert I. Ko, Amyn A. Malik, Dennis Wang, Mike Wang, Daniel M. Weinberger, Saad B. Omer

This study aimed to assess the potential of sewage sludge monitoring to track outbreaks of SARS-CoV-2 in the community. This article is a preprint and has not been peer reviewed.

QUESTION The PICO of the study is as follows;

P – community

Indicator /C – Sewage sludge SARS-CoV-2 RNA concentration

O – COVID-19 cases (identified as COVID-19 admissions to the local hospital and laboratory confirmed cases in the community)

METHODS This study assessed the correlation between SARS-CoV-2 RNA detected in sewage sludge and local hospital admission data and community COVID-19 cases in the New Haven area in Connecticut, USA between March 19 and May 1 2020. Daily primary sludge samples were collected from the wastewater treatment facility and SARS-CoV-2 RNA was quantified by a one-step quantitative reverse transcriptase-polymerase chain reaction using a commercial kit (optimized for isolation of total RNA from soil) and primer sets (N1 and N2) from the US Centre for Disease Control. Analysis for the human Ribonuclease P (RP) gene was performed as a control. First sampling dates were prior to widespread individual testing in the region and the start of statewide stay at home restrictions. Daily COVID-19 admissions to New Haven Hospital were compiled from hospital records and confirmed by laboratory testing. Community cases were compiled from daily reports published by the state department of health.

RESULTS The method of quantifying SARS-CoV-2 RNA concentration values was valid; replicated samples demonstrated similar concentration values and the comparison of primer values with the control indicated that temporal concentration changes in RNA were from actual change in virus concentration.

The study found that the peak of viral concentration in sewage sludge occurs 3 days earlier than the peak hospital admissions (Figure 1) and 7 days earlier than peak in COVID-19 community cases (Figure 2). The correlation coefficient between RNA and hospital data when the hospital data was shifted 3 days forward was 0.996 and 0.994 when COVID-19 testing data was adjusted 7 days forward.

DISCUSSION The following points were discussed;

The correlation coefficients presented in the study were obtained from analysis of smoothed time series data. Smoothing is applied to remove some of the random variation in the data, but such analysis may inflate observed correlations. However, use of raw time series data, which would likely be 'lumpy' owing to reporting and processing delays in hospital admissions and identification of cases (e.g. as may occur over weekend periods), is likely to 'dilute' any observed correlations. After discussion, there was agreement that a correlation exists, but it is likely to be overstated.

There was some discussion about the shorter lag period for hospital admissions (3 days) than new cases (7 days). It was thought this may reflect difference in symptom severity with people presenting to hospital becoming more ill more quickly than milder cases, who are unlikely to present to hospital and take longer to be tested in the community.

There was discussion about the practical application of this method. Timely information on outbreak dynamic may assist in the provision of advice to increase testing when subsequent waves of infection are anticipated in an area and the implementation or easing of restrictions. Testing of flight or cruise ship sewage, with further testing of passengers if any virus detected, was another possibility. Given the method uses routinely generated medium and standard techniques, it was thought there could be many useful applications though there is a need to ensure reliability – areas adopting this method would need to conduct a validation study.

OVERALL SUMMARY This was a well conducted and reported study suggesting that SARS-CoV-2 sludge monitoring can accurately track outbreaks in a community. Further, the method may be a leading indicator of hospital admissions and community COVID-19 cases, though the correlations between the virus RNA and COVID-19 cases and hospital admissions observed in this study may be inflated.

Figure 1 Rescaled smoothed SARS-CoV-2 virus RNA concentrations (red line) and hospital admissions (grey line)
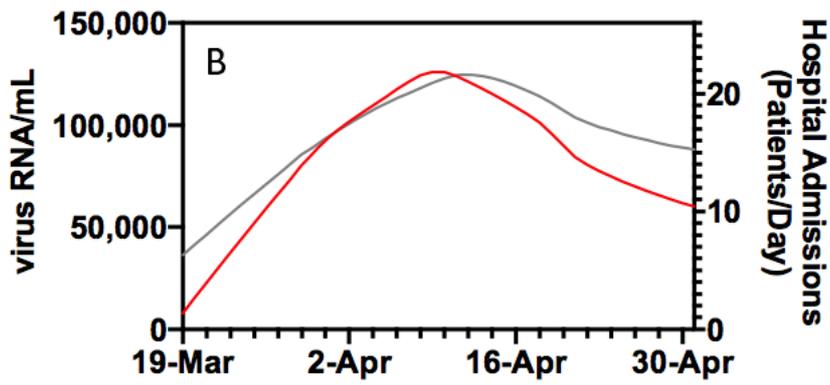

Figure 2 Rescaled smoothed SARS-CoV-2 virus RNA concentrations (red line) and COVID-19 new cases (grey line)