POTENTIAL OF SEWAGE SURVEILLANCE IN EARLY DETECTION OF COVID-19

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In the prevailing pandemic, recognizing and eventually isolating infected people is the need of the hour. Present testing methods tend to take their share of time to identify positive samples, then the authorities initiate communication with infected persons, and necessary precautions are taken. This process takes time, keeping the target person to be an individual, but where we need to get a broad idea of the virus spread in a community, a suitable, effective, and efficient method should be applied, which brings us to sewage surveillance for COVID-19 spread. The concept of mass sewage surveillance for a check on epidemics supports the requirement of individual testing and suggests potential hotspots. Sewage samples taken up from a community are tested on common testing platforms, and their results can give a bigger picture of the infection in that particular community. Other infections, such as polio, have been effectively detected via sewage testing. Several studies related to this methodology have been coming up recently, making sewage samples a source of testing rather than individual testing. It saves time and effort, and eventually, we move towards better governance in public health. This review paper looks at the various studies done under sewage surveillance in different parts of the world, emphasizing their critical points.

Keywords: Wastewater Based Epidemiology, COVID-19, Public health, Sewage Surveillance

1 INTRODUCTION

The world is in the middle of a pandemic, the first time on such a large scale in this modern era of humanity. With technological advancements in the last century, we face new hazards. The pandemics represent an advanced danger to humankind. Emerging as a hotspot for new cases, the Coronavirus interrupted socio-economic operations in nations such as China, the United Kingdom, Italy, and India (J. J. Van Bavel et al. 2022). Although the recovery rate is commendable compared with other countries with more advanced medical facilities, the testing and reporting of COVID-19 are questioned by many reputed authorities.

Before curing, one has to identify the problem, and we can't subscribe to medicine if we are not sure if we are infected, resulting in COVID testing. Government and private labs are taking up this responsibility to perform testing of samples as quickly as possible (Huang et al. 2020; Shahbazi and Khazaei 2020). The essential part to note here is the time these agencies are clocking in this process because it serves as the first link in the chain of events to follow after testing and its result. The commonly used diagnosis technique in the present scenario is Reverse Transcriptase-Polymerase Chain Reaction (RT-PCR). However, specific mass screening puts immense strain on the existing lab facilities and takes its share of time. This problem limits the feasibility of this approach to testing.
Different Geoenvironmental factors were found to be responsible for the worldwide spread of COVID-19, but human activities played an essential role in the severity of this transmission (Amuedo-Dorantes, Kaushal, and Muchow 2021). Thus different countries came out with different sets of rules and regulations to fight this battle against the virus, which suggests urban composition, social factors, and regional politics played an essential role in the decision-making process (Tian et al. 2020; Sharifi and Khavarian-Garmsir 2020; Barak, Sommer, and Mualam 2021). To date, various studies have been conducted to relate several factors responsible for the worldwide transmission of COVID-19. From testing possible infections to finding suitable protection measures, the critical factor was early detection to avoid the mass spread. One thing mutually inclusive in a community with disease spread is the water people consume and the characteristics of the sewage disposed of from that area. As per WHO, COVID doesn't transmit through drinking water. Hence, the authors highlight sewage (“Estimating Mortality from COVID-19: Scientific Brief, 2020). Earlier, sewage surveillance has proved to be an effective technique in the fight against infectious diseases by scientists and virologists, whether it's Polio in Israel or Hepatitis in the U.K. (“Sewage Provides Early Warning for Polio” 2017; Smith, Paddy, and Simmonds 2016). So, it can be inferred that surveillance of Covid-19 in sewage samples can be used as an epidemiological tool and a marker of virus transmission, allowing for the implementation of suitable preventive measures in a specific catchment region. The samples were examined on RT-PCR equipment to see if the SARS-CoV-2 virus was present in the wastewater via fragments of genetic material (RNA). Figure 1 depicts the workflow chart involved in Wastewater Based Epidemiology (WBE). The ease of testing with WBE models allows testing a wide population even when limited sources are available for testing (National Wastewater Surveillance System (NWSS) – CDC, 2020). Therefore, this paper targets the possible WBE-based studies related to COVID-19 detection and their key findings. The paper also targets the locations and the methods used for early detection for their potential use.
2 STUDIES ON MASS SURVEILLANCE DURING THE PANDEMIC

The literature mentioned in Table 1 has been considered to study and track down the means of COVID-19 detection through sewage and wastewater surveillance. As there is only a limited number of studies explicitly conducted targeting wastewater as the possible method for detecting COVID-19 strains, the literature review focused on different observations from different parts of the world during this pandemic.

Table 1. Studies and findings related to sewage and wastewater surveillance.

<table>
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<tr>
<th>Study</th>
<th>Year</th>
<th>Location</th>
<th>Major Findings</th>
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| De Jong et al. 2020           | 2020 | Rotterdam               | - SARS-CoV-2 detected in sewage after wastewater disposal. 
- Viral components found in feces 1 to 2 days before clinical respiratory symptoms onset. |
| WHO Scientific Brief, 2020    | 2020 | Various                 | - Non-infectious RNA fragments of SARS-CoV-2 found in untreated wastewater and sludge. 
- Changes in SARS-CoV-2 RNA detected days before COVID-19 cases identified by clinical surveillance. |
| Sherchan et al. 2020          | 2020 | Louisiana, USA          | - SARS-CoV-2 RNA detected in wastewater samples using ultrafiltration. 
- Detection in wastewater started when COVID-19 cases were reported in the respective locations. |
| Kumar et al. 2020             | 2020 | India                   | - SARS-CoV-2 viral genes (ORF1ab, N, and S) found in wastewater discharge. 
- Debate on SARS-CoV-2 infectivity in the aquatic environment via viral genetic material. |
| Martínez-Puchol et al. 2021   | 2021 | Various                 | - Next Generation Sequencing (NGS) is used to examine excreted virome comprehensively. 
- Human Coronaviridae members found in one wastewater sample. |
| Bhattacharya et al. 2021      | 2021 | Various                 | - Emphasized the importance of standard procedures for sample collection and viral RNA analysis. 
- Physiochemical characteristics of water linked to accurate estimation. |
| Karthikeyan et al. 2021       | 2021 | San Diego, USA          | - GIS-enabled wastewater monitoring detected over 85% of COVID-19 infections on a university campus. |
| Xu et al. 2021                | 2021 | Hong Kong               | - Sewage sample from the COVID-19 hospital had the highest viral concentration (1975 copy/mL). 
- Detected undisclosed COVID-19 instances in two apartment complexes, aiding control measures. |
Deng et al. 2022 2022 Hong Kong
- Workflow of testing techniques developed to avert the Delta variant outbreak.
- Clone Manager 8.0 was used to assess primer and probe sequences for different dimerization.

Amereh et al. 2022 2022 Tehran, Iran
- WBE was found to be essential for monitoring not only COVID-19 but also future viral outbreaks.

Araújo et al. 2022 2022 Brazil
- SARS-CoV-2 strains detected in sewage samples from municipal and airport-based STPs.
- Omicron variant resulted in faster emergence of viral concentrations in Belo Horizonte.

Gonçalves et al. 2022 2022 Various
- Challenges implementing WBE surveillance systems, favoring decentralized WTTP-based testing.
- Need for environmental surveillance of CoV-2 RNA in contaminated water.

Jakaria et al. 2022 2022 Bangladesh
- SARS-CoV-2 genetic materials detected in urban and rural areas with onsite WBE system recommendation.
- Strong presence of SARS-CoV-2 in city drains, isolation facilities, and communal ponds.

3 DISCUSSION

The literature review presented in the table showcases various studies conducted to explore the presence of SARS-CoV-2 in wastewater and its potential significance in COVID-19 surveillance. The studies collectively highlight the utility of WBE as a tool for early detection and monitoring of COVID-19 outbreaks. Several studies detected SARS-CoV-2 RNA in untreated wastewater and sludge samples before clinical cases were identified, demonstrating the potential of WBE to serve as an early warning system. Moreover, the viral genetic material in wastewater, even before the onset of clinical respiratory symptoms, suggests the potential use of sewage surveillance for timely intervention.

Advanced techniques, such as NGS, enable comprehensive analysis of excreted virome, providing insights into the circulation of SARS-CoV-2 and related viruses in the environment. These studies also emphasize the need for standardized procedures in sample collection and viral RNA analysis to ensure accurate results. Despite its promise, WBE faces challenges, particularly in decentralized settings and developing nations with inadequate sewage management. Nevertheless, successful implementation, as demonstrated in various locations, offers the potential to detect COVID-19 infections in specific areas and control viral spread effectively.
4 CONCLUSIONS

The encouraging findings of the research encourage us to look for other ways to use sewage monitoring technology in a broader range of applications to aid with COVID-19 management. Detecting early warning indicators in communities to identify mild and asymptomatic instances is vital for establishing successful methods to help reduce disease spread before symptoms appear. More studies are required to adapt sewage monitoring from academic research to a public health management tool. A few things, namely virus mutation, the extensive incubation periods, regular viral shedding, and spread among asymptomatic and pre-symptomatic infected patients, contribute to the outbreak's difficulty in control. Wastewater-based disease surveillance is being pushed in public health for monitoring community outbreaks; the interrelations between wastewater virus titers and the number of documented clinical studies in the community are not proportional. Despite this, the technique is improving significantly over the pandemic.

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References


Impact of Previous Exposure to SARS or MERS on Control of the COVID-19 Pandemic.”


