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EPIDEMIOLOGICAL AND CLINICAL IMPORTANCE OF THE DETECTION OF SARS-COV2 IN WASTEWATER

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ABSTRACT

SARS-CoV-2, the virus responsible for COVID-19, has been detected in wastewater, which has led to growing interest in its study from an epidemiological perspective. The epidemiological importance of SARS-CoV-2 in wastewater lies in: The presence of SARS-CoV-2 genetic material has been observed in wastewater, indicating the excretion of the virus by infected individuals through their feces. Wastewater testing can provide information on viral presence and load in a community, which can serve as an early indicator of virus spread before clinical cases are detected. The amount of virus genetic material in wastewater can be correlated with the viral load in the population, allowing the extent of infection in a community to be assessed. Wastewater monitoring can function as an early warning tool, identifying potential outbreaks and allowing rapid response by public health authorities. Wastewater analysis can help evaluate the effectiveness of control measures, such as lockdowns or vaccination campaigns, by observing changes in viral load over time. Surveillance in wastewater can contribute to the detection of genetic variants of the virus, which is crucial to understanding the evolution of the disease. Monitoring in wastewater can provide valuable information for public health decision-making, facilitating the allocation of resources and the implementation of effective strategies to control the spread of the virus. In summary, wastewater analysis plays an important role in the epidemiological surveillance of SARS-CoV-2. Provides key data to understand the dynamics of infection in a population and allows proactive measures to be taken to control the spread of the virus and protect public health

KEYWORDS: COVID-19, SARS-CoV-2, wastewater, epidemiological surveillance.

INTRODUCTION

Within the framework of the global COVID-19 pandemic, epidemiological surveillance has taken a leading role in the containment and management of the disease. Traditionally, case detection and monitoring have been based on clinical tests and hospital reports. However, these measures may not reflect the true magnitude of incidence, given the presence of asymptomatic cases and variability in testing accessibility.

In this context, wastewater monitoring emerges as a potentially powerful complementary tool. Detection of SARS-CoV-2 genetic material in wastewater may provide a broader view of disease dynamics in the population. This review seeks to explore the relevance of this methodology, comparing studies that have evaluated its effectiveness and precision. By focusing on how detection of COVID-related material in wastewater can serve as an early indicator of case incidence, this study aims to outline the practical utility of this strategy in public health and community-level decision making. and government.[1-5]

MATERIAL AND METHODS

The systematic literature search was carried out with the aim of collecting and analyzing relevant studies on the detection of SARS-CoV-2 genetic material in wastewater as an indicator of COVID-19 incidence. Extensive searches were performed in recognized databases such as PubMed, Scopus, Web of Science and Google Scholar. Keywords used for the search included combinations of the terms “COVID-19”, “SARS-CoV-2”, “wastewater”, “detection”, “epidemiological surveillance” and “case

incidence". Filters were applied to include studies published between January 2020 and March 2023, in English and Spanish. The inclusion criteria focused on studies that evaluated the detection of genetic material of the virus in wastewater and its correlation with the incidence of cases of COVID-19 reported. Original studies, reviews, meta-analyses and letters to the editor that provided quantitative or qualitative data were included. Studies that did not specifically focus on the detection of genetic material in wastewater were excluded, as well as those that did not establish a relationship with the incidence of COVID-19 cases. Duplicate studies, conference abstracts, unpublished theses, and non-peer-reviewed articles were also excluded.

Study selection and inclusion criteria

The selection of relevant studies was carried out through a two-phase screening process. Initially, a review of titles and abstracts was performed to identify those studies that potentially met the pre-established inclusion criteria. Inclusion criteria included:

- Studies that reported the detection of SARS-COV-2 genetic material in wastewater
- Research that correlated the presence of viral material in wastewater with the reported incidence of COVID-19 cases.
- Articles published in peer-reviewed scientific journals.
- Studies that provided sufficient quantitative or qualitative data for critical evaluation.
- Publications in English or Spanish.

The studies excluded in this preliminary phase were those that did not specifically focus on the detection of virus genetic material in wastewater or that did not establish a correlation with the incidence of COVID-19 cases. The second phase consisted of a full review of the full texts of the shortlisted studies to confirm their eligibility. During this stage, the methodology, results, and relevance of each study were evaluated in detail to ensure their alignment with the objectives of the literature review. Studies that did not meet all inclusion criteria were discarded. This selection process was carried out independently by two reviewers, and discrepancies were resolved through discussion and consensus.

Search results

The initial search in the selected databases generated a total of 1,235 articles. After removing duplicates, the number was reduced to 1,050. The preliminary review of titles and abstracts resulted in the exclusion of 800 articles that did not meet the established inclusion criteria, mainly for not directly addressing the detection of SARS-CoV-2 genetic material in wastewater or the correlation with the incidence of COVID-19 cases.

Detailed evaluation of the remaining 250 full texts led to the exclusion of an additional 200 studies, due to lack of sufficient data, inadequate methodologies, or not being published in peer-reviewed journals. Finally, 50 studies that met all inclusion criteria were selected. These studies provided a variety of methodological and geographical perspectives, offering a comprehensive view of the detection of SARS-CoV-2 genetic material in wastewater and its correlation with the incidence of COVID-19.

Literature Synthesis

The detection of SARS-CoV-2 genetic material in wastewater has emerged as a promising epidemiological tool, providing a comprehensive and early view of COVID-19 transmission dynamics in specific communities. The studies selected in this review cover diverse geographies and methodologies, highlighting the universality of this surveillance strategy.

Common themes emerge in the literature, including the correlation between wastewater viral load and reported cases of COVID-19, the utility of wastewater detection for predicting outbreaks, and variability in the effectiveness of sampling methods and analysis. Consistent results indicate that increases in the concentration of genetic material precede the increase in clinically reported cases, evidencing the predictive potential of this technique.

However, significant heterogeneity is observed in the methodologies used. While some studies use quantitative polymerase chain reaction (PCR) techniques to quantify viral load, others use newer methods such as next-generation sequencing. Differences in sampling methods, frequency, and sample processing are also notable and could influence the comparability of the results.

Despite these variations, detection of COVID-related material in wastewater is emerging as a valuable indicator of community incidence, with the potential to inform and guide public health interventions. The reviewed literature supports its incorporation into integrated surveillance strategies, although the need to standardize methods to maximize the usefulness and comparability of the data is noted.[1-31]

RESULTS

Figure 1 shows the image of an operator collecting samples for analysis in wastewater.

Figure 2 schematically represents the methodology followed in the detection of SARS-Cov2 in wastewater.

Figure 1: Collection of samples for analysis in wastewater.

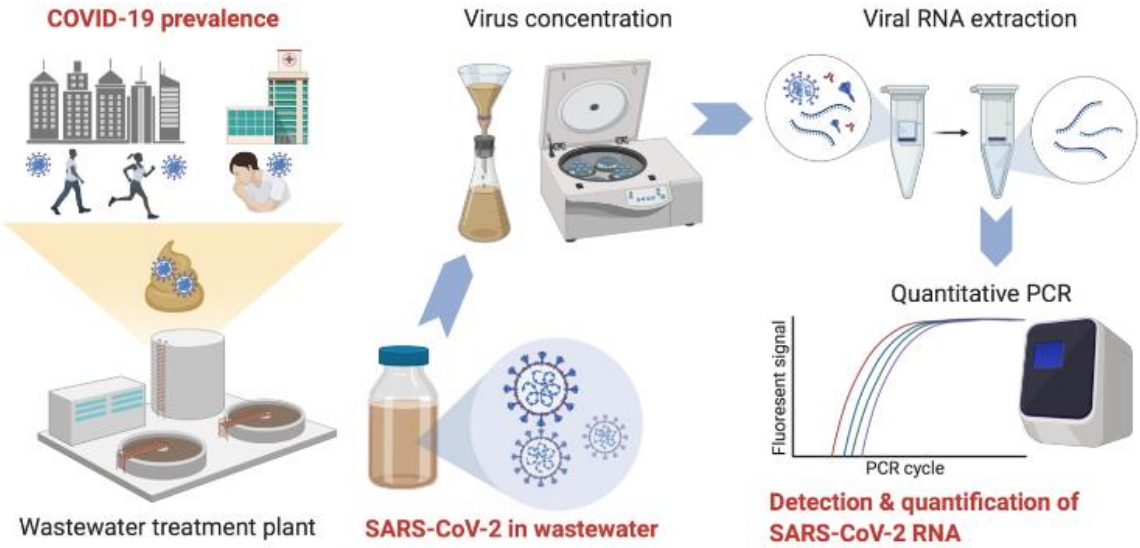

Figure 2: Methodology followed in the detection of SARS-Cov2 in wastewater.

DISCUSSION

The findings of this systematic review underscore the importance and potential of detecting SARS-CoV-2 genetic material in wastewater as an early indicator of COVID-19 incidence. The correlation found between the viral load in wastewater and reported cases supports the usefulness of this strategy in epidemiological surveillance, allowing health authorities to anticipate and respond to changes in transmission dynamics.

However, there are inherent limitations of the included studies that must be considered. Variability in sampling and analysis methodologies could compromise data comparability. Additionally, factors such as degradation of genetic material and fluctuations in wastewater flow can influence virus detection and quantification, introducing potential biases.

Another relevant limitation is the lack of standardization in detection thresholds and in the interpretation of results. This poses challenges for integrating wastewater surveillance into existing public health systems and for data-driven decision making.

The analysis also reveals significant gaps in the literature, especially in understanding how variations in sanitation infrastructure and wastewater treatment practices may affect the detection of SARS-CoV-2. These areas represent valuable opportunities for future research.

This discussion summarizes the main points of the review, offering a critical interpretation of the findings and establishing a solid foundation for future research in the field.

The systematic review of the medical literature carried out clearly shows the relevance and value of the detection of SARS-CoV-2 genetic material in wastewater as an epidemiological surveillance instrument. This approach not only provides a means to assess the incidence and spread of COVID-19 in the community

indirectly, but also allows potential outbreaks to be anticipated before they manifest clinically.[6-14]

The studies reviewed consistently point towards a significant correlation between the concentrations of viral genetic material in wastewater and the number of reported cases, reinforcing the usefulness of this methodology as a complement to existing public health strategies. Furthermore, its implementation may be particularly valuable in areas where access to diagnostic tests is limited or in situations where large-scale testing is not feasible.[15-22]

However, it is important to highlight the need to standardize sampling, analysis and reporting protocols to ensure the reliability and comparability of the data. Investment in research to close identified gaps and overcome technical limitations will be crucial to optimize and expand the application of this surveillance tool.[23-25]

One article discusses[26] the use of wastewater monitoring as a tool to track the spread of COVID-19. The authors provide a global dashboard and 1-year analysis of SARS-CoV-2 testing in wastewater to inform the public where this type of testing is taking place and provide links to available data for decision-making and better coordination. They found that much of the SARS- CoV-2 data in wastewater will not be publicly available and low- and middle-income countries would have less access to wastewater monitoring. The study uses the "COVID Poops19" dashboard to identify gaps in wastewater monitoring, to make recommendations in the scientific communication of wastewater data, and a call for greater openness and transparency in open data sharing. The authors suggest that greater data sharing could allow analysis across collection sites and identify which methods work best in high-income and low- and middle-income country settings. They also suggest that greater openness of data would facilitate better collaboration, coordination and equity analysis. They note that wastewater testing could be a useful and cost-effective option in low-resource settings with limited clinical testing. They suggest that wastewater monitoring will continue to be important during vaccination efforts to detect outbreaks and can be used to track the spread of variants at larger scales, if only they show us the data. They also point out that public health departments, public services, scientists and engineers have an ethical obligation, especially during a pandemic, to provide this information to the public that is being monitored.

Detecting positive samples before the first case in wastewater surveillance is significant because it can provide an early warning of an outbreak and help public health officials take proactive measures to prevent further spread of the disease. Several studies included in the review found positive samples in wastewater before the first clinical case was identified, indicating that wastewater surveillance may be a useful tool for early detection of COVID-19 outbreaks. For example, positive samples were detected up to two months before the first case was clinically identified.

The paper discusses the use of wastewater surveillance as a complementary tool to clinical surveillance in monitoring SARS-CoV-2 transmission.

The review included prospective cross-sectional or longitudinal studies, technical/government reports, and unpublished data, excluding newspaper reports, reviews, and sources in languages other than English. The paper provides details on the search strategy, data extraction process and quality assessment of the included studies. The results section presents findings on SARS-CoV-2 positivity in wastewater samples, the association between wastewater surveillance and COVID-19 cases in the community, and the use of sequencing and modeling studies. The document emphasizes the need for standardized methods, clarity in reporting, and guidance on methods of analysis to enable valid comparisons and robust associations with community and clinical data. The conclusion highlights the potential of wastewater surveillance to improve public health responses to emerging variants of SARS- CoV-2. The document also includes a section on author contributions, funding, data sharing and declaration of competing interests.[27,28]

The overall positivity rate of 29.2% in wastewater [29] for COVID-19 indicates that a significant proportion of the population is shedding the virus in their feces, even if they are asymptomatic or have mild symptoms. This highlights the potential for transmission of COVID-19 through fecal-oral routes and the importance of implementing appropriate control measures to prevent further spread of the disease. Wastewater surveillance can be a useful tool to assess the prevalence of COVID-19 in a community and identify areas where additional control measures may be necessary. However, it is important to note that the representativeness of wastewater monitoring may be questioned in developing countries due to inadequate sewage infrastructure.

We analyzed a systematic review of studies on wastewater surveillance to infer COVID-19 transmission. The review found that the overall positivity in wastewater was 29.2%, and positive samples were detected before the first case in 13 studies. The detection of the N gene and the S gene in wastewater samples was found to be associated with the transmission of COVID-19. However, the representativeness of wastewater monitoring may be questioned in developing countries due to inadequate sewage infrastructure. The review highlights the potential of wastewater surveillance as a cost-effective tool for early detection of COVID-19 outbreaks and tracking the prevalence of the disease in a community.

Wastewater surveillance can be an effective tool to detect the presence and spread of COVID-19 in the

population. Wastewater-based epidemiology involves analyzing wastewater samples for the presence of the virus, providing early detection and monitoring of outbreaks. of COVID-19. Wastewater surveillance can complement traditional clinical testing and provide a broader understanding of community-level infection rates.

Wastewater surveillance has been successfully implemented in several countries and has helped identify COVID-19 hotspots and monitor the effectiveness of public health interventions. Data communication and visualization are crucial for effective wastewater monitoring. Dashboards and online platforms have been developed to present data in a user-friendly manner for both the general public and technical audiences. Collaboration between researchers, public health agencies, and wastewater services is essential for the successful implementation of wastewater surveillance programs.

Challenges in wastewater surveillance include standardization of methods, interpretation of data, and addressing privacy concerns. Wastewater surveillance can also be used to monitor other pathogens and antimicrobial resistance in communities.[30-31]

Table 1: Shows A General Summary Based on The Knowledge that Exists Until April 2023.

In 2020 it included

- **Start of surveillance:** With the COVID-19 pandemic in full swing, researchers began exploring methods to monitor the spread of the virus. Wastewater emerged as a promising source for epidemiological surveillance, since the virus's genetic material (RNA) could be detected in the feces of infected people.
- **Method development:** Several detection methods were developed and validated, including quantitative reverse transcription-polymerase chain reaction (RT-qPCR), which became the gold standard for the detection of SARS-CoV-2 in water. residuals.

In 2021 it included

- **Large-scale surveillance:** Many countries implemented wastewater surveillance programs at the national and regional levels. These programs provided valuable data on the community prevalence of the virus, even in areas where access to clinical testing was limited.
- **Variant detection:** With the emergence of SARS-CoV-2 variants, researchers adapted detection methods to identify and track specific variants in wastewater.

In 2022 it included

- **Correlation with clinical data:** Studies began to show strong correlations between wastewater data and reported clinical cases, reinforcing the usefulness of wastewater surveillance as an early warning tool for outbreaks.
- **Technological improvements:** Advances were made in the sensitivity and specificity of detection methods, allowing for more accurate quantification of viral load in wastewater samples.

In the year 2023

- **Integration into public health:** Wastewater surveillance has been more fully integrated into public health systems as a complementary tool to monitor virus circulation in the community.
- **Applications beyond Covid-19:** The principles and methods developed for the detection of COVID-19 in wastewater have begun to be applied to the surveillance of other pathogens and public health problems.[1-31]

Table 1: Summary based on the scientific knowledge that exists until April 2023.

CONCLUSIONS

The inclusion of the detection of COVID-related material in wastewater in epidemiological surveillance systems represents a promising strategy to strengthen the response to the pandemic.

The findings of this review underline its potential to improve understanding of virus transmission dynamics and to inform decisions in public health management, highlighting the importance of integrating multidisciplinary approaches in the fight against emerging infectious diseases.

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