Wastewater sequencing analyses uncover pathogen evolution and spread

IDM
May 23rd, 2023
Clinical sampling blind spots

Brito, Semenova, Dudas et al., 2021
Clinical sampling blind spots

Brito, Semenova, Dudas et al., 2021

Lieberman-Cribbin et al., 2020

Rader, Astley et al., 2020
Wastewater as a promising alternative

![Graph showing reported cases per 100,000 and viral load in wastewater over time from Feb 2021 to Jun 2022. The graph indicates a correlation between reported cases and viral load, with peaks coinciding around Jan 2022. SARS-CoV-2]
Wastewater as a promising alternative

![Graph showing reported cases and viral load in wastewater over time. The graph includes two lines: one representing reported cases and the other representing viral load in wastewater. The x-axis represents time from June 05 to January 29, and the y-axis represents the viral load copies per PMMoV.]
Wastewater as a promising alternative

Decoupling
Need a new approach for wastewater sequencing analyses

Wastewater samples are fundamentally mixtures, with mutations linked by their frequency in the sample.
Lineage Barcoding

>3000 SARS-CoV-2 lineages

Turakhia et al., 2021
Lineage Barcoding

Detection of Single Nucleotide Variants

>3000 SARS-CoV-2 lineages
Lineage Barcoding

Detection of Single Nucleotide Variants

Depth-weighted de-mixing

\[ \hat{x} = \arg \min_{x \geq 0, \sum x = 1} \| A^T x - b \|_1 \]

>3000 SARS-CoV-2 lineages
The BA.1 Omicron wave in San Diego

~1.5% Nov 27 Dec 8

~2.3 million individuals in catchment
The BA.1 Omicron wave in San Diego
Ongoing real-time surveillance in San Diego

Growth rate estimation from wastewater

<table>
<thead>
<tr>
<th>Lineage</th>
<th>Growth Advantage</th>
<th>Bootstrap 95% CI</th>
</tr>
</thead>
<tbody>
<tr>
<td>XBB.2.3.X</td>
<td>15.4%</td>
<td>[3.05%, 32.75%]</td>
</tr>
<tr>
<td>XBB.1.16.X</td>
<td>9.0%</td>
<td>[3.29%, 17.37%]</td>
</tr>
<tr>
<td>XBB.1.9.X</td>
<td>5.9%</td>
<td>[1.53%, 10.31%]</td>
</tr>
<tr>
<td>XBB.X</td>
<td>3.0%</td>
<td>[-4.69%, 9.73%]</td>
</tr>
<tr>
<td>XBB.1.5.X</td>
<td>-7.5%</td>
<td>[-10.90%, -3.48%]</td>
</tr>
</tbody>
</table>
Haplotype recovery, phylogenetics, outbreak tracking
Wastewater surveillance across the world

Wastewater surveillance in Blantyre, Malawi
Wastewater surveillance in South Africa with NICD
SARS-CoV-2 waves in South Africa via wastewater
Integrated wastewater and clinical surveillance
Integrated wastewater and clinical surveillance
Integrated wastewater and clinical surveillance
Integrated wastewater and clinical surveillance
Freyja availability and usage

>80k downloads
Acknowledgements