SARS-CoV-2 Wastewater Surveillance and Public Health Applications in Houston, TX

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24-hour composite influent/wastewater samples are collected from 39 wastewater treatment plants (serving 2.3M+), 51 schools, 25 congregate living facilities (nursing homes, homeless shelters, jail), and 60 lift stations each week.

SARS-CoV-2 in quantified in replicate samples in two independent laboratories (Rice and Baylor).

Variant tracking performed using targeted assays and SARS-CoV-2 genome sequencing.

Raw data is input into statistical models that identify geographic areas of concern with significant increases in wastewater virus concentration.

Sites with putative variants of concern present are identified and confirmation is pursued via sequencing of PCR-positive clinical samples.

Health department uses wastewater data in cluster analysis to prioritize interventions at zip-code level.
Statistical Analysis

- **Manage** complexities of compiling data from one or two labs
- **Communicate** viral load levels
  - Levels as a percent of the July 6, 2020 viral load
  - Percent one-week change of estimated levels
- **Translate** to the zip code level
- **Continue to refine** prediction of prevalence in Houston

SARS-CoV-2 in Wastewater is an Early Indicator of Observed Clinical Case Count

The lead time is 1 to 2 weeks.
Wastewater Treatment Plant Level

ALMEDA SIMS
9.47 MGD; Pop. 330,126

BELTWAY
5.20 MGD; Pop. 134,557

SAGEMONT
3.14 MGD; Pop. 67,929

EASTHAVEN
1.18 MGD; Pop. 46,111
Summary Graphs across all WWTPs

Relative Viral Load Levels at WWTPs since July 6, 2020

Percent One-Week Change in Viral Load at WWTPs since July 6, 2020
Wastewater Variant Tracking

Targeted assay (ddPCR) for the detection of specific mutations

Sequencing of SARS-CoV-2 genomes from wastewater samples for more comprehensive screening of variants of concern.
For each variant of concern (VOC) and variant of interest (VOI), there are a set of characteristic mutations that define it.

- Identified a subset of characteristic mutations as **indicative** mutations for each variant. **Indicative** mutations were defined as:
  - found in >90% of all genomes of sequenced variants
  - not found consistently (<30%) in sequenced genomes of other variants
- Also report the **total** number of characteristic mutations detected for each variant in each sample
  - Indicative mutations are a subset of the characteristic mutations.
Example at the Zip Code Level

Plateauing levels at zip code

77025

Decreasing levels at zip code

77008
Cluster Analysis

Variables included in the Cluster Analysis Report

<table>
<thead>
<tr>
<th></th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Top 15 Zip Codes by Historical Positivity Rate</td>
</tr>
<tr>
<td>2</td>
<td>Number of Times the Zip Code has Repeated</td>
</tr>
<tr>
<td>3</td>
<td>Historical Positivity Rate</td>
</tr>
<tr>
<td>4</td>
<td>Past 5 Weeks Positivity Rate</td>
</tr>
<tr>
<td>5</td>
<td>Historical Vaccination Rate</td>
</tr>
<tr>
<td>6</td>
<td>Cumulative Positive Cases</td>
</tr>
<tr>
<td>7</td>
<td>Number of Active Positive Cases</td>
</tr>
<tr>
<td>8</td>
<td>Race Information (ACS Data)</td>
</tr>
<tr>
<td>9</td>
<td>Percent Hispanic (ACS Data)</td>
</tr>
<tr>
<td>10</td>
<td>Families Below Poverty Level (ACS Data)</td>
</tr>
<tr>
<td>11</td>
<td>Facilities with Sensitive Sub Populations</td>
</tr>
<tr>
<td>12</td>
<td>WWTP(s) Within the Zip Code</td>
</tr>
<tr>
<td>13</td>
<td>Percent of Jul 6 20 Copies/Day (WWTP)</td>
</tr>
<tr>
<td>14</td>
<td>Percent of UK Variant (WWTP)</td>
</tr>
<tr>
<td>15</td>
<td>Percent of Jul 6 20 Copies/Day (Zip Code)</td>
</tr>
<tr>
<td>16</td>
<td>Percent of UK Variant (Zip Code)</td>
</tr>
<tr>
<td>17</td>
<td>Confirmed PCR UK Variant Case Count (Zip Code)</td>
</tr>
<tr>
<td>18</td>
<td>Estimated WWTP Trend for the Zip Code</td>
</tr>
<tr>
<td>19</td>
<td>Number of Addresses - 5 or More Active Positive Cases</td>
</tr>
<tr>
<td>20</td>
<td>List of Addresses - 5 or More Active Positive Cases</td>
</tr>
<tr>
<td>21</td>
<td>Number of Times the Address has Repeated</td>
</tr>
<tr>
<td>22</td>
<td>Overall Count of Positive Cases at the Address</td>
</tr>
<tr>
<td>23</td>
<td>Count of Active Positive Cases at the Address</td>
</tr>
<tr>
<td>24</td>
<td>Address Type</td>
</tr>
<tr>
<td>25</td>
<td>Description of Address</td>
</tr>
<tr>
<td>26</td>
<td>Response Actions for the Address</td>
</tr>
<tr>
<td>27</td>
<td>Median Age of Active Cases at the Address</td>
</tr>
<tr>
<td>28</td>
<td>Minimum Age of Active Cases at the Address</td>
</tr>
<tr>
<td>29</td>
<td>Maximum Age of Active Cases at the Address</td>
</tr>
<tr>
<td>30</td>
<td>Date of Most Recent Positive Test at the Address</td>
</tr>
<tr>
<td>31</td>
<td>WWTP for the Address</td>
</tr>
</tbody>
</table>

- Top 15 zip codes by overall positivity rate
- Cluster defined as an address with 10 or more cases in the past 5 weeks
- Incorporate wastewater surveillance findings, vaccination rates, demographic data
### Example Cluster Report

<table>
<thead>
<tr>
<th>Zip Code Count of Facilities with Sensitiv Subpopulations</th>
<th>WWTP(s) Within the Zip Code</th>
<th>WWTP % of Jul 6-20 Copies/Day (9/8/21 Data)</th>
<th>WWTP % of Jul 6-20 Copies/Day (9/8/21 Data)</th>
<th>Zip Code % of UL Variant (9/8/21 Data)</th>
<th>Estimated Wastewater Trend for the Zip Code (9/8/21 Data)</th>
<th>Locations in Zip Code with 5 or More Positive Cases (Past 5 Weeks)</th>
<th>List of Locations with 10 or More Positive Cases (Past 5 Weeks)</th>
<th>Repeat (Count)</th>
<th>Overall Count of Positive Cases at the Location</th>
<th>Past 5 Weeks Count of Positive Cases at the Location</th>
<th>Location Type</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>869 Street</td>
<td>Imperial Valley</td>
<td>112%</td>
<td>42%</td>
<td>67%</td>
<td>92%</td>
<td>Downward/Platou</td>
<td>No Locations with 10 or More Active Positive Cases in the Past 5 Weeks</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>0</td>
<td>Sims Bayou 69th Street</td>
<td>112%</td>
<td>42%</td>
<td>67%</td>
<td>92%</td>
<td>Downward/Platou</td>
<td>No Locations with 10 or More Active Positive Cases in the Past 5 Weeks</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>0</td>
<td>1111 MAIN ST</td>
<td>Repeat (8)</td>
<td>81</td>
<td>10</td>
<td>Apartment</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>0</td>
<td>1112 MAIN ST</td>
<td>Repeat (4)</td>
<td>44</td>
<td>10</td>
<td>Apartment</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>0</td>
<td>MUD#203 Imperial Valley</td>
<td>112%</td>
<td>42%</td>
<td>67%</td>
<td>92%</td>
<td>Downward/Platou</td>
<td>No Locations with 10 or More Active Positive Cases in the Past 5 Weeks</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>0</td>
<td>No Locations with 10 or More Active Positive Cases in the Past 5 Weeks</td>
<td>Repeat (4)</td>
<td>44</td>
<td>10</td>
<td>Apartment</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>0</td>
<td>Locations identified with 5 or More Active Positive Cases in the Past 5 Weeks Were Single Family Homes</td>
<td>Repeat (4)</td>
<td>44</td>
<td>10</td>
<td>Apartment</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>0</td>
<td>No Locations with 10 or More Active Positive Cases in the Past 5 Weeks</td>
<td>Repeat (4)</td>
<td>44</td>
<td>10</td>
<td>Apartment</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Examples of Maps from Cluster Report

Maps represent simulated, de-identified data
## Top 15 Zip Codes

Each week corresponds to a cluster report and reflects the ranking, by overall positivity, of the top 15 zip codes for that week.

|------|-------|--------|--------|--------|-------|--------|--------|--------|-------|--------|--------|--------|-------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|
Wastewater Surveillance at Schools and Congregate Living

Wastewater Surveillance Manhole Report

- **Designate** sites as:
  - High Positive
  - Lower Positive
  - Unclear
  - Negative

- **Identify** spikes or increases in wastewater viral load
### Wastewater Surveillance Manhole Report

#### High Positives (7) total
- Nursing Home 1 [4]++
- School 3 [3]++
- School 2 [1]++
- School 4 [0]++
- School 6 [1]++

#### Lower Positives (4) total
- School 7 [0] +
- School 8 [1] +
- School 9 [0] +
- School 10 [1] +

#### Unclears (6) total
- Jail 1
- Nursing Home 2
- School 11
- School 12
- School 13
- Shelter 2

#### Negatives (50) total
- Nursing Home 6
- Nursing Home 7
- Nursing Home 8
- Nursing Home 9
- Shelter 3
- Shelter 4
- Shelter 5
- Shelter 6
- Shelter 7
- Shelter 8
- Shelter 9
- Shelter 10
- School 14
- School 15
- School 16
- School 17
- School 18
- School 19
- School 20
- School 21
- School 22
- School 23
- School 24
- School 25
- School 26
- School 27

#### Negatives (50) total cont.
- School 28
- School 29
- School 30
- School 31
- School 32
- School 33
- School 34
- School 35
- School 36
- School 37
- School 38
- School 39
- School 40
- School 41
- School 42
- School 43
- School 44
- School 45
- School 46
- School 47

[8] signifies the number of weeks in a row a location tested positive from manhole wastewater samples

++ signifies high levels of >10,000 copies/L; + signifies lower levels <10,000 copies/L

Data Collected: 4/26/2021
### Wastewater Surveillance at Schools

<table>
<thead>
<tr>
<th>School Name and Wastewater Sample results</th>
<th># Cases Reported by School Since 4/26/21</th>
<th># of PCR / Confirmed Cases since 4/26/21</th>
<th>Last Assessment</th>
<th>Compliant with School Check List (Yes/No)</th>
<th>Outbreak? (Yes/No)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Elementary 1 [3] ++</td>
<td>0</td>
<td>0</td>
<td>12/2/2020</td>
<td>Yes</td>
<td>No</td>
</tr>
<tr>
<td>Elementary 2 [1] ++</td>
<td>1</td>
<td>0</td>
<td>12/4/2020</td>
<td>Yes</td>
<td>No</td>
</tr>
<tr>
<td>Elementary 3 [2] ++</td>
<td>0</td>
<td>0</td>
<td>12/4/2020</td>
<td>Yes</td>
<td>No</td>
</tr>
<tr>
<td>Early Childhood 1 [0] ++</td>
<td>0</td>
<td>0</td>
<td>12/2/2020</td>
<td>Yes</td>
<td>No</td>
</tr>
<tr>
<td>Middle 1 [3] ++</td>
<td>2</td>
<td>1</td>
<td>12/7/2020</td>
<td>Yes</td>
<td>No</td>
</tr>
<tr>
<td>High School 1 [1] ++</td>
<td>1</td>
<td>1</td>
<td>12/7/2020</td>
<td>Yes</td>
<td>No</td>
</tr>
</tbody>
</table>

Interdepartmental effort to combine wastewater surveillance and clinical assessment findings

- Outbreak Response Schools Team working in conjunction with Wastewater Surveillance Team
- Notify school district superintendent and school principal of wastewater results
- Notify HISD Nurse liaison of wastewater results
- Maintain active outreach with school for **10 days or until wastewater is negative**

[#{#}] signifies the number of weeks in a row a location tested positive from manhole wastewater samples

++ signifies high levels of >10,000 copies/L; + signifies lower levels <10,000 copies/L
Interdepartmental effort to combine wastewater surveillance and clinical assessment findings

- Outbreak Response Schools Team working in conjunction with Wastewater Surveillance Team
- Notify school district superintendent and school principal of wastewater results
- Maintain active outreach with school for 10 days or until wastewater is negative
### Facility Name and WW Sample results

<table>
<thead>
<tr>
<th>Facility Name and WW Sample results</th>
<th>Last Clinical Testing at Facility</th>
<th># of PCR / Confirmed Cases Since 2/1/21</th>
<th>Last Assessment</th>
<th>Compliant (Yes/No)</th>
<th>Vaccination Date</th>
<th># of consecutive weeks of positive results (staff/residents)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Jail, Jail 1 [3] ++</td>
<td>2/10/2021</td>
<td>680</td>
<td>n/a</td>
<td>Yes</td>
<td>-</td>
<td>Since May 2020</td>
</tr>
<tr>
<td>NH, Nursing Home 1 [9] ++</td>
<td>2/8/2021</td>
<td>0</td>
<td>1/22/2021</td>
<td>Yes</td>
<td>1/8/2021, 2/1/2021</td>
<td>Last case was on 1/13/2021</td>
</tr>
<tr>
<td>NH, Nursing Home 2 [3] ++</td>
<td>2/8/2021</td>
<td>0</td>
<td>1/22/2021</td>
<td>Yes</td>
<td>1/4/2021</td>
<td>6 weeks Last case was on 1/28/2021</td>
</tr>
<tr>
<td>NH, Nursing Home 3 [2] ++</td>
<td>2/4/2021</td>
<td>5</td>
<td>1/20/2021</td>
<td>Yes</td>
<td>1/19/2021, 1st dose</td>
<td>3</td>
</tr>
<tr>
<td>NH, Nursing Home 4 [11] ++</td>
<td>2/8/2021</td>
<td>0</td>
<td>01/25/2021</td>
<td>Yes</td>
<td>01/06/2021, 01/27/2021</td>
<td>0</td>
</tr>
<tr>
<td>Shelter, Shelter 1 [0] ++</td>
<td>5/28/2020</td>
<td>0</td>
<td>05/20/2020</td>
<td>Yes</td>
<td>-</td>
<td>0</td>
</tr>
<tr>
<td>NH, Nursing Home 5 [1] +</td>
<td>1/26/2021</td>
<td>0</td>
<td>1/29/21</td>
<td>Yes</td>
<td>1/5/21, 1/26/21</td>
<td>Last case 1/25/2021</td>
</tr>
</tbody>
</table>

[0] signifies the number of weeks in a row a location tested positive from manhole wastewater samples

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---

**Interdepartmental effort to combine wastewater surveillance and clinical assessment findings**

- **Outbreak Response Team** working in conjunction with Wastewater Surveillance Team
- **Notify facility director** of wastewater results and **confirm if a new active outbreak**
  - If new outbreak, conduct onsite assessment and facility testing with mobile testing unit
Interdepartmental effort to combine wastewater surveillance and clinical assessment findings

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Questions?