Development and Application (and lessons already learned) of Passive Air Sampler to Assess Personal Exposure to SARS-CoV-2

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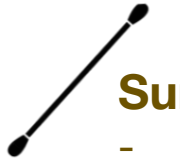
Tracking Infections Using Environmental Virus Surveillance

As COVID-19 cases persist and masking requirements are lifted, environmental surveillance is an attractive complementary approach.

Air monitoring can identify virus in the air before individuals develop symptoms.

Airborne viral levels are a magnitude lower than levels in the nose (~1000+ RNA copies). Measuring virus in the air is challenged by the need for a sensitive technology to detect low virus levels (<100 RNA copies). Antigen and NAAT testing is not suitable for analyzing air samples.

Available Surveillance Techniques Limit Personalized Assessment of Infection Risk



Surface Swabs

- Focus on fomite transmission
- Fixed location

Active Aerosol Samplers

Air drawn through a filter with a pump

- Fixed location
- Power required
- Loud
- Expensive hardware ($10k+)

Fresh Air Clip

Wearable Passive Sampler

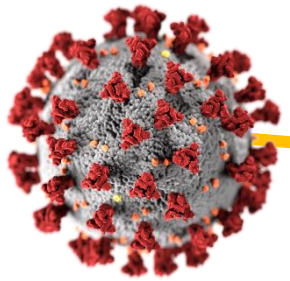
Aerosols and droplets taken up on a polymer film

- Wearable device to capture personal exposure
- No power required
- Silent
- Low-cost, reusable hardware

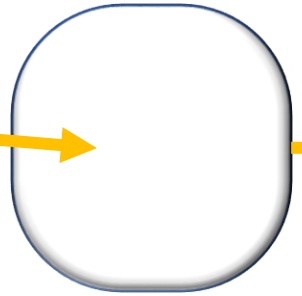
Current technologies restrict assessment at a fix location which do not accurately capture a person's exposure.

Personalising air monitoring tools can provide early warning of transmission risk that is specific to the wearer or provide information on practices or environments with a high risk of exposure.

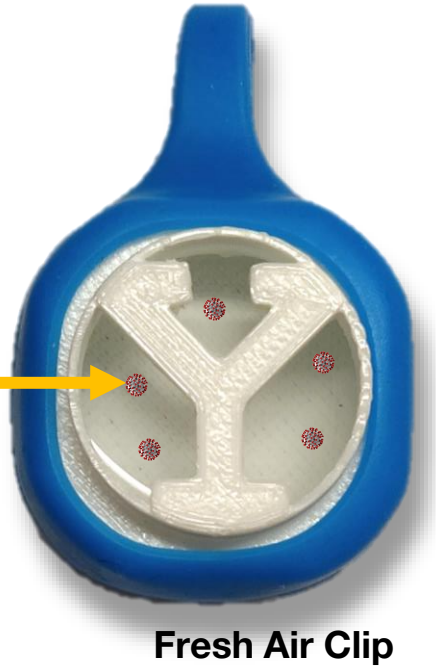
Development and Validation of a Wearable Sampler



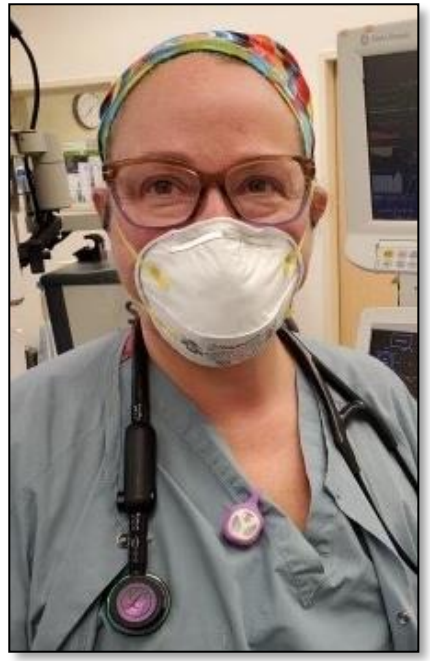
SARS-CoV-2



Polymer Film



Fresh Air Clip



1 **Demonstration that passive sampling can be used to collect airborne virus**

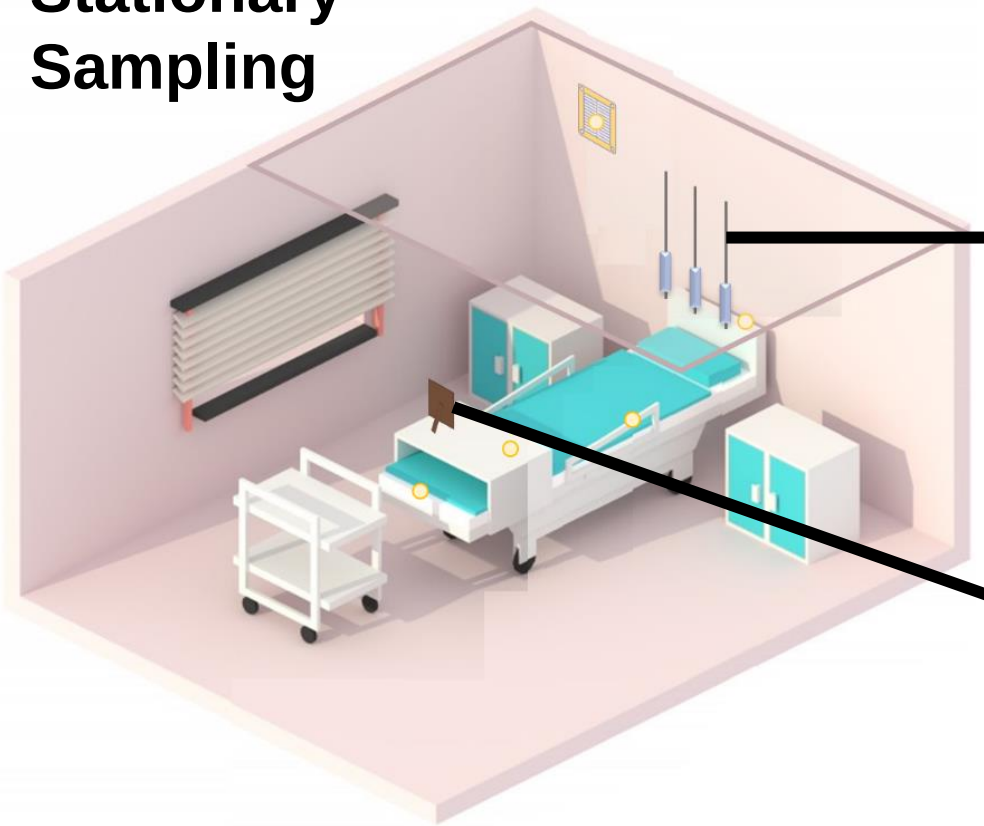
2 **Development of methods to quantify collected virus**
RNA copies/clip

3 **Estimate airborne virus exposure levels**
RNA copies m^{-3}

4 **Assessment of viral exposure in high risk environments**

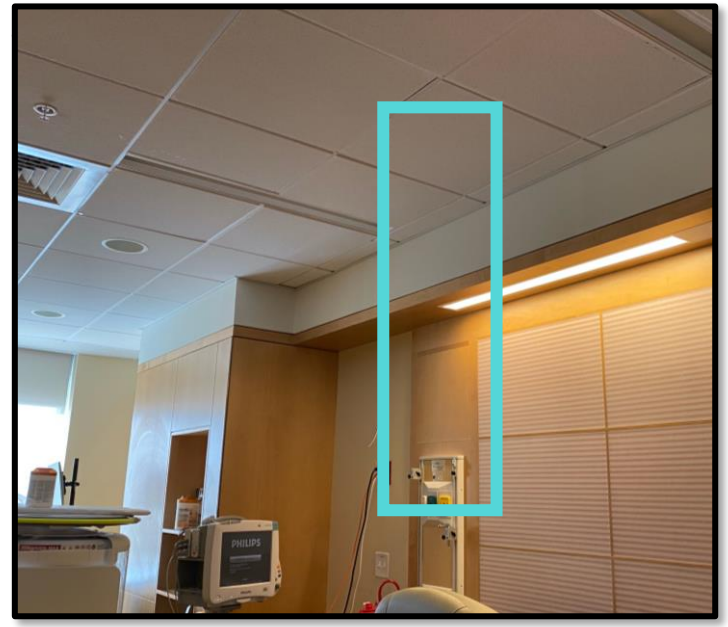
Detection of SARS-CoV-2 in the Air

Stationary Sampling



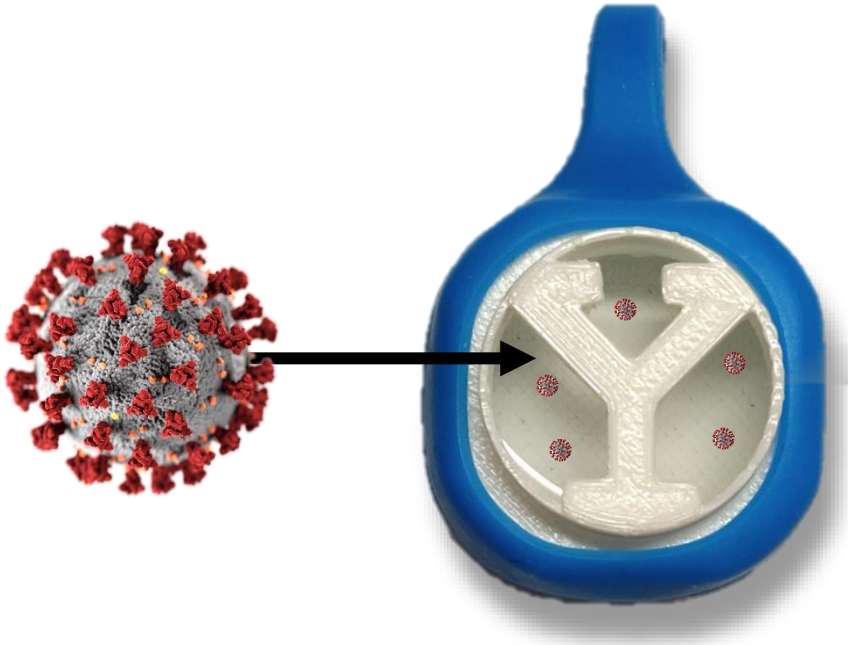
Ceiling suspended air samples

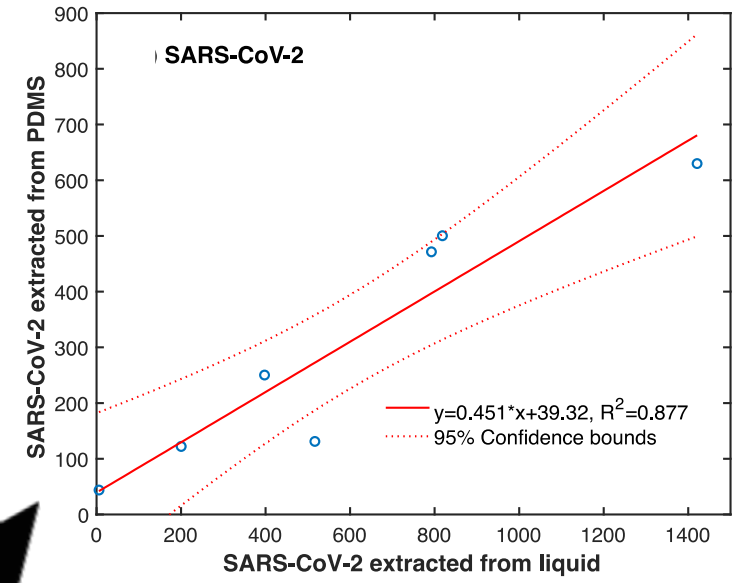
Ceiling Suspended Air

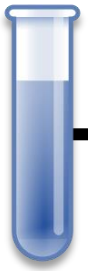


Bedside Picture Frame Air Sampler

What is the sensitivity of this exposure assessment approach?



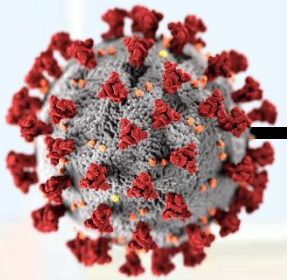




Collected SARS-CoV-2 extracted from sorbent in passive air sampler
45% extraction efficiency

Virus levels measured using digital droplet PCR
Minimum detection limit of 6 RNA copies/clip

What are virus exposure levels in the air?



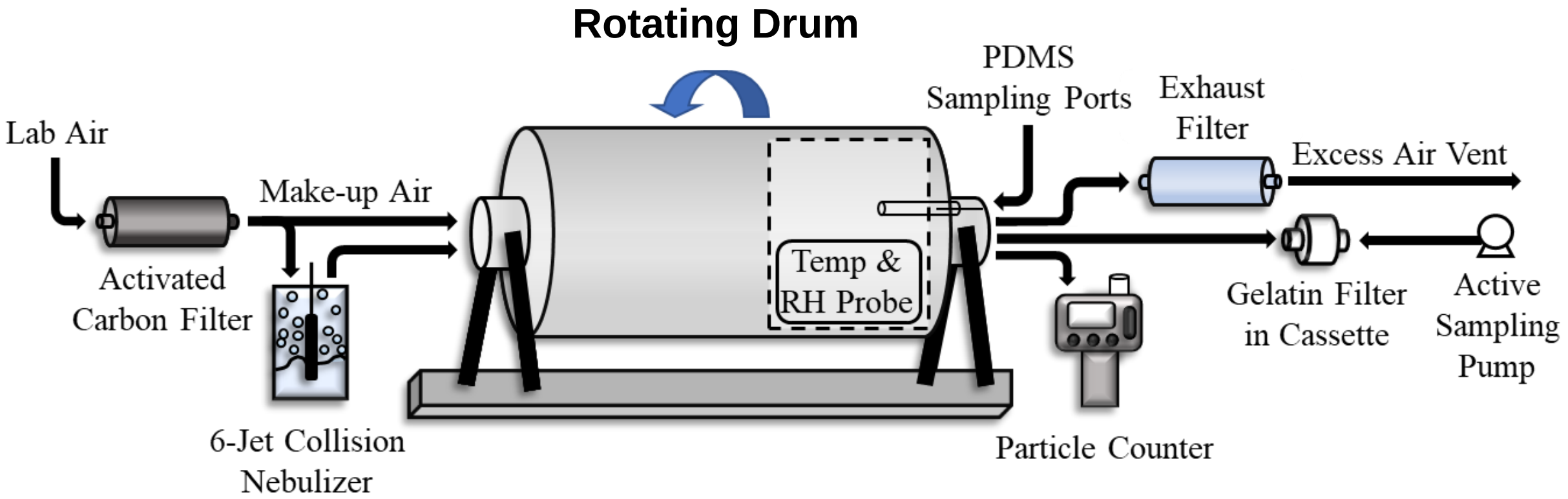
Rate of Uptake

How quickly are virus-laden aerosol collected by the passive air sampler?

Testing the rate of uptake requires an environment with stable levels of virus in the area.

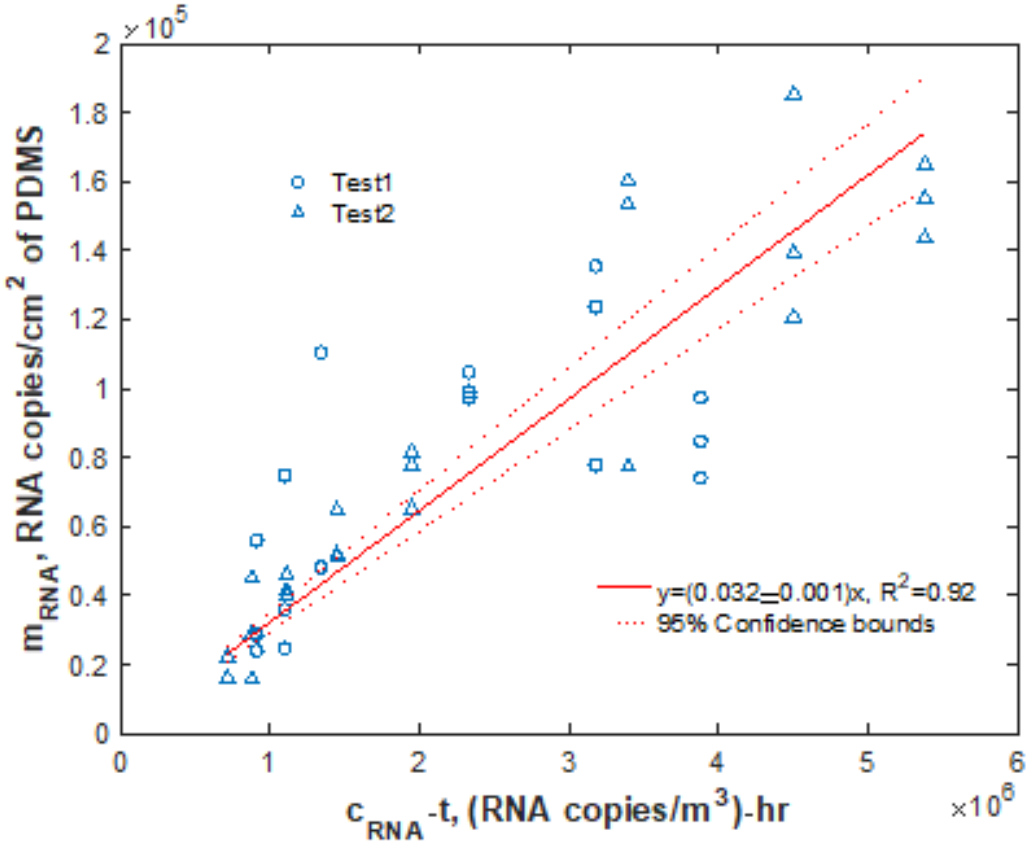
Simulated Indoor Space in the Laboratory

Generate an environment with a known concentration and distribution of virus-laden aerosol that is stable over extended periods.

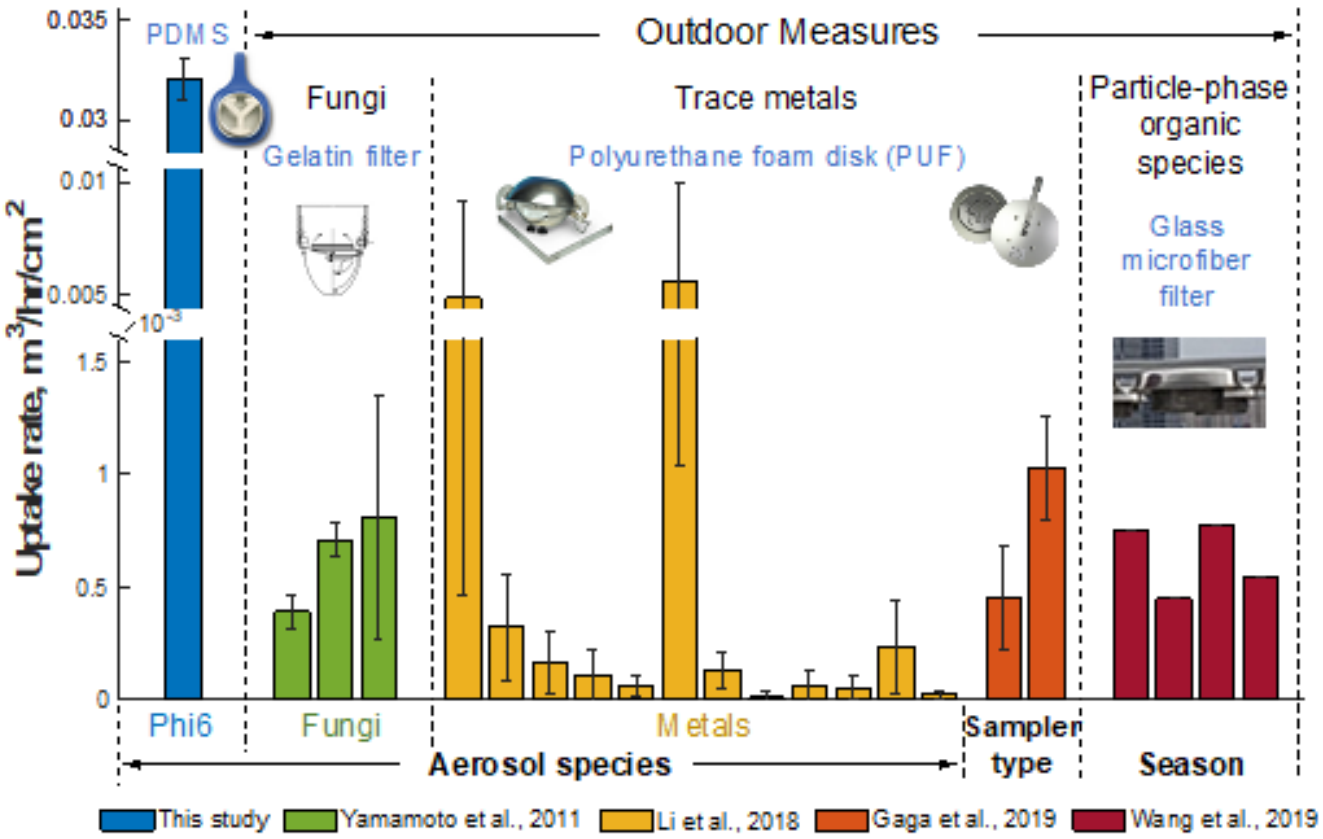


Virus Uptake by the Fresh Air Clip

Linear Uptake



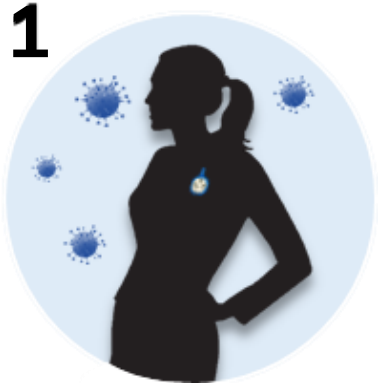
Fresh Air Clip Design Optimises Uptake



Using the uptake rate we can express virus exposures as RNA copies per m^3 of air.

Fresh Air Clip: Exposure to Detection

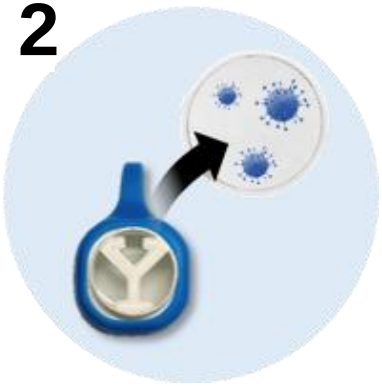
1



A Fresh Air Clip is worn by an individual to continuously monitor viral exposure.

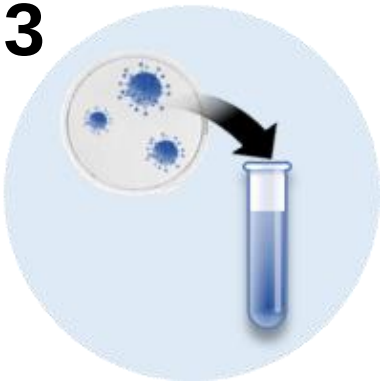
Assessment period with the clip can vary from one day (during outbreaks) to multiple days.

2



Airborne SARS-CoV-2 is collected on a polymer film in the Fresh Air Clip designed for efficient aerosol uptake.

3



Following wear, the Fresh Air Clip is returned to a lab for viral analysis.

Collected SARS-CoV-2 is extracted using optimized methods from the polymer film.

4

Extracted virus is measured using gold-standard PCR protocols.

Method are highly sensitivity with a lower detection limit of 6 virus copies on the clip.

5

SARS-CoV-2 exposure results are reported back on an interactive dashboard with alerts of elevated levels.

Personalized protective actions are recommended.

Personal exposure trends are tracked over time.

Assessment of Personal Exposure to Airborne SARS-CoV-2 in High Risk Settings

Clip worn for 5 days during work shifts

62 participants assessed in January to May 2021

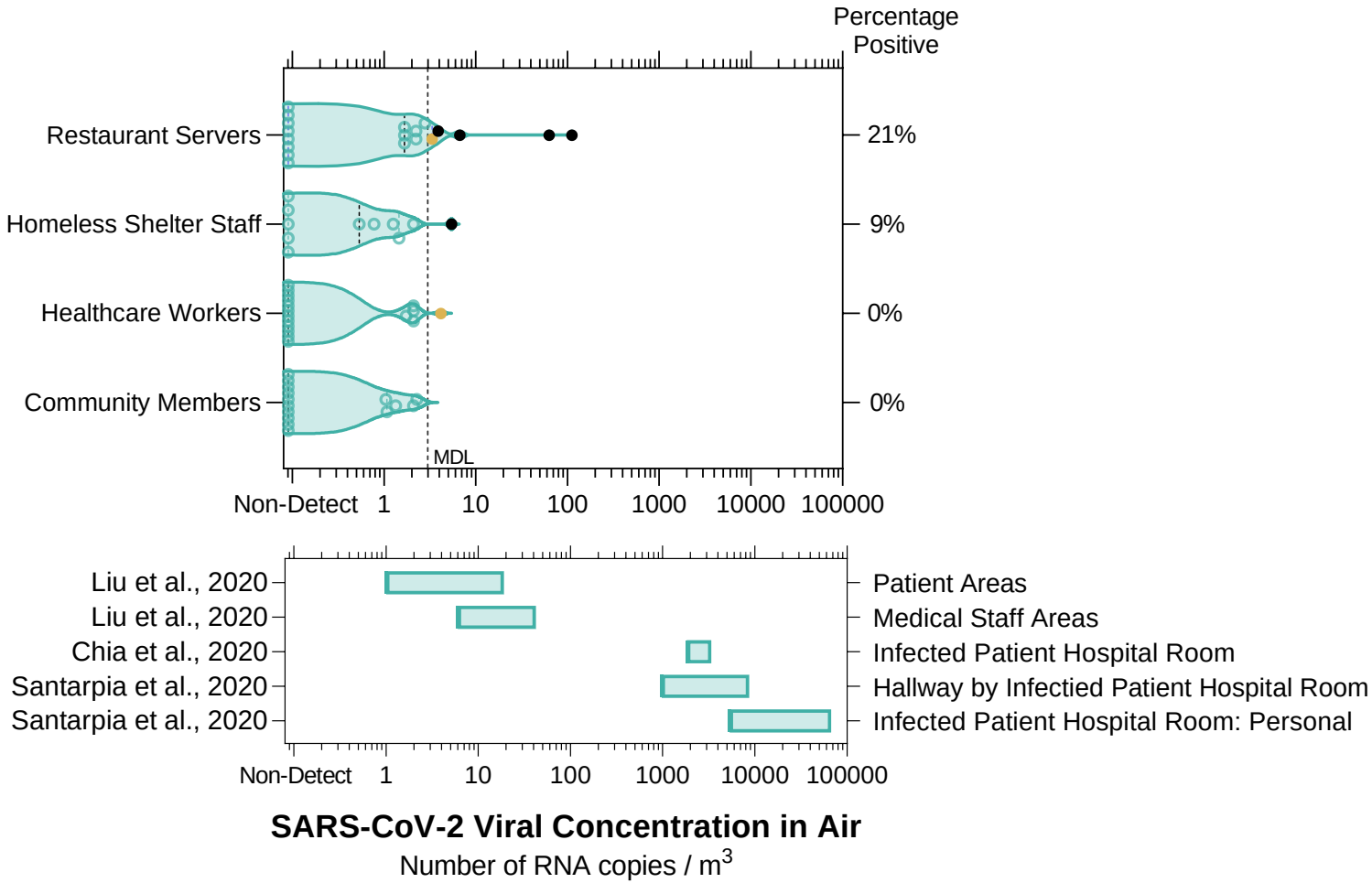
Assessment Location	Samplers Collected	Sampling Months in 2021	Mask Mandate	Averaged Estimated SARS-CoV-2 Daily Case Rate (cases/100,000 people)
Restaurants	19	March-May	No (while patrons were eating)	27.2
Healthcare Facilities	17	January-April	Yes	39.5
Community	15	March-May	Varied	26.2
Homeless Shelter	11	March-May	Yes	19.0

Assessment of Personal Exposure to Airborne SARS-CoV-2 in High Risk Settings

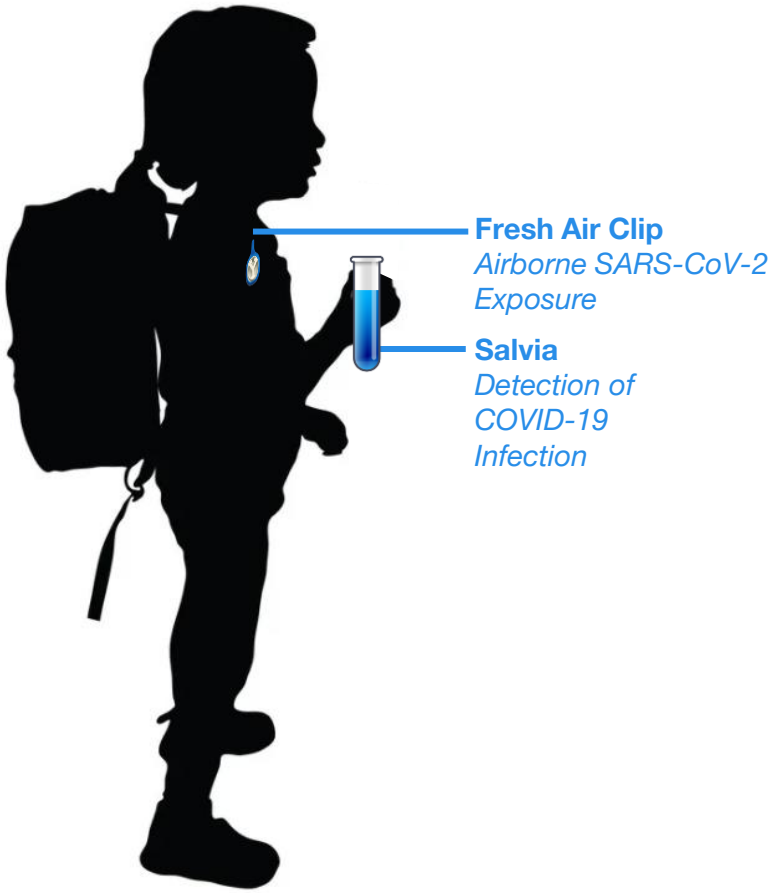
SARS-CoV-2 exposure detected for 8% of participants.

Airborne levels ranged from 4 to 112 RNA copies per cubic meter.

The highest and most frequent exposures found for restaurant servers.

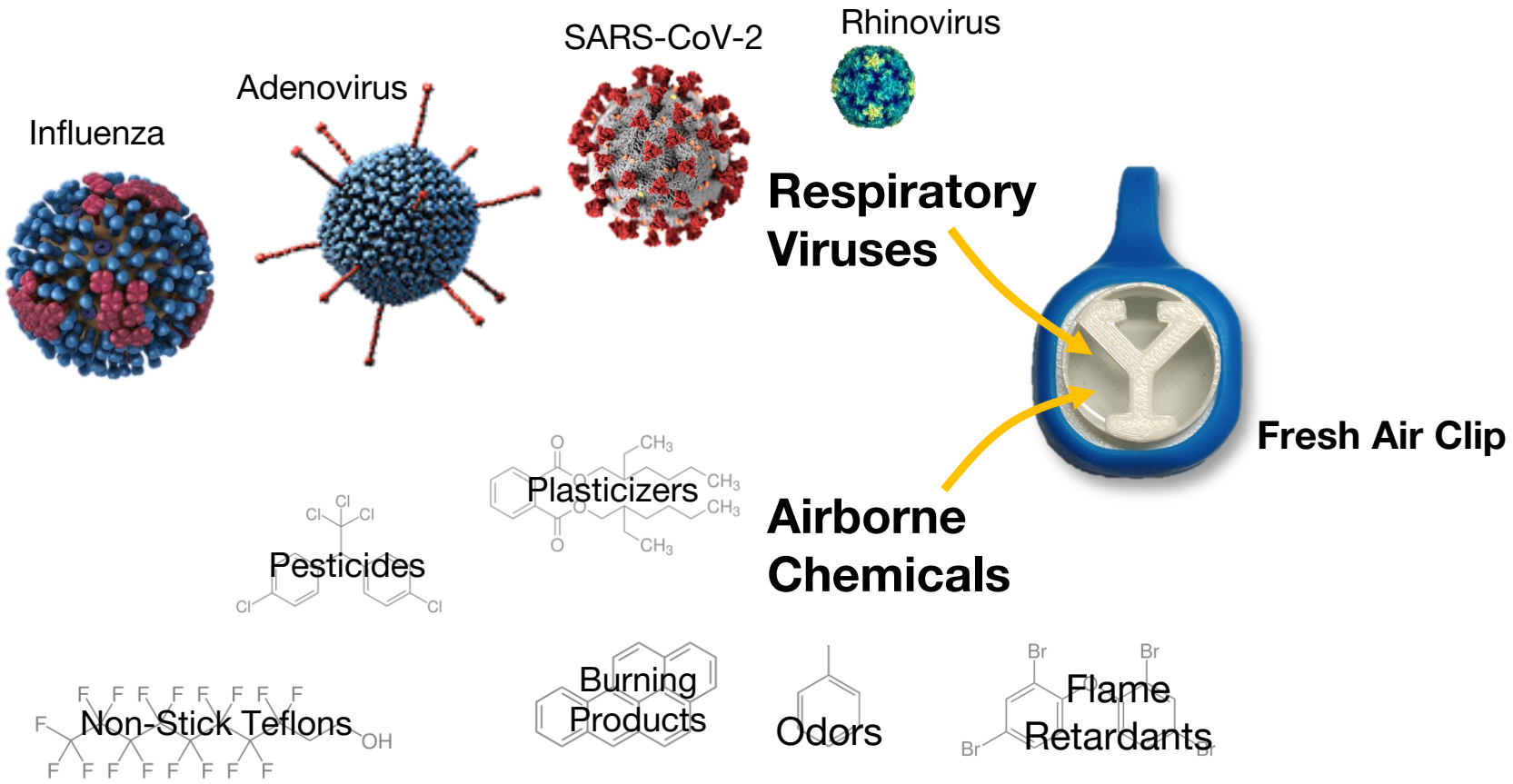


Future Directions: Link between Airborne SARS-CoV-2 Transmission and COVID-19 Infection



Evaluate the relationship between personal exposure to detected airborne SARS-CoV-2 and COVID-19 infection in 100 children and teachers in five New Haven day cares.

Future Directions: Expansion to Include Comprehensive Pathogen and Chemical Surveillance



Clip Development Made Possible by a Strong Interdisciplinary Team

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Letter

Development and Application of a Polydimethylsiloxane-Based Passive Air Sampler to Assess Personal Exposure to SARS-CoV-2

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