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CUBE: COVID-19 in the Urban Built Environment

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Disclosures

- Dr. Note: None
- Dr. Fralick is a consultant for ProofDx a start-up company that has created a point of care test for COVID-19 using CRISPR

Learning Objectives

- To appreciate how surface sampling for SARS CoV2 correlates with clinical cases of COVID-19
- To describe how these results might allow for early identification of outbreaks within long-term care homes

Wastewater sampling



https://www.thestar.com/news/gta/2020/10/14/ottawa-sewage-shows-alarming-spike-incovid-19-transmission.html; Mathew McCarthy / Waterloo Region Record

Surface swabbing



https://www.dnagenotek.com/





COVID-19 in the Urban Built Environment



SARS-CoV-2 detection from the built environment and wastewater and its use for hospital surveillance

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- 1. Recovered viral RNA
- 2. Predominantly recovered from floors >> high-touch surfaces
- 3. COVID "hot spot" areas
- 4. In non-COVID ward, detected during outbreak only
- 5. Association between positivity rate of floor swabs, hospital wastewater signal and inpatient COVID activity











Proportion of hospital floor swabs positive for SARS-CoV-2 (bars) and mean hospital COVID-19 active cases (line)





Campus A wastewater SARS-CoV-2 copies per mL (bars) and mean hospital COVID-19 active cases in Campus A (line)





How generalizable are these results to other settings?

Universities

Long-term care homes





University of Ottawa

uOttawa

- Buildings identified in collaboration with the Campus Reintegration Task Force
- High and low traffic sites identified within each building
- Matched CO₂ data
- Building-level wi-fi data



uOttawa

- Cases for students & employees
- Black rug lines indicate data at which a positive test was reported



UOttawa Model

Probability of cases from model (top sections) aligned with cases data (middle) and swab results (bottom) for six buildings.





Developed by Dr. Samir K. Sinha, Dr. Ryan Doherty, Rory McCleave, and Julie Dunning, National Institute on Ageing, Ryerson University. Data curated by the NIA Long-Term Care COVID-19 Tracker Open Data Working Group. Tracker Methodology & Disclaimer



Study design

- Multicentre prospective study Sep 2021 Aug 2022
- Once weekly swabbing (10-24 per building)
- Weekly carbon dioxide from half the homes
- Outbreak data reported from long-term care homes









One LTC Home



Another LTC



Summary of Results

- 3,848 swabs collected at 10 long-term care homes
- 19 COVID-19 outbreaks during the study period
 - Median size was cases 34 (2-150)
- Floor swab results
 - 51% (95% CI 48-53) positive during outbreaks
 - 18% (95% Cl 17-19) when no outbreak
- Among 8 LTCH with an outbreak and swabs performed in the weeks prior to the outbreak starting, 5 had floor swab positivity exceeding 10% five or more days prior to the outbreak being identified.

Outbreak Detection Performance

	%	% of positive swabs			
	10%	30%	50%		
PPV	51% (42-60)	64% (53-74)	72% (58-83)		
NPV	93% (86-97)	86% (79-91)	81% (74-86)		

Stratified results by location

	Overall	Outbreak	Staff cases	No cases	
Percentage of PCR-positive swabs					
All locations	28.9 (27.5-30.4)	50.1 (47.4-52.8)	12.8 (9.4-17.1)	18.9 (17.3-20.6)	

How does the viral burden change over space and time?

Study design

- Patient's hospitalized at one of two hospitals
- Hospitalized on the ward and in a private room
- Floor swabbed twice daily for the first 4 days at the following locations from the hospital bed: 1m, 2m, 3m+

Results

- 180 swabs collected from 15 rooms
- 89% of floor swabs detected SARS-CoV2
 - Day 0: 81% positive
 - Day 2: 98% positive
- Median cycle threshold of 34 (IQR 32, 38)

Strengths

- Size: 10,000+ swabs (and counting!)
- Scope: University campus, LTC, hospital, (schools & daycares)
- Strength of association: most clear in LTC setting
- Spatial refinement: supported by hospital and LTC data

Limitations

- Outbreak definition is imperfect
- Can floor swabs mitigate outbreaks?
- Sustainability

Future Directions

- Adapting technique for other pathogens
- Quality improvement study ongoing at two hospitals
- Grant(s) under review for implementation study at LTCs

Funding

- CIHR
- NSERC
- University of Ottawa

uOttawa

Appendix

Check out our website!

Cube-Ontario.github.io

Study design

- Prospective cohort study of multiple built environments
- Homes, university sites and schools represented a convenience sample

	uOttawa	LTC	Schools
Number of locations	2 sites x 6 buildings across the uOttawa main campus	10 in Toronto, Ottawa, Sault Ste Marie	6 schools (OCDSB, CECCE) 2 infant-toddler programs 1 special needs school
Locations	Undergrad residence Central admin Main library Gym Classrooms Support staff	Common and staff areas (dining, nursing station, lounges, staff locker rooms, lobby)	Every classroom Staff common rooms Gyms
Sampling: 2"x2" area	1 swab twice weekly, Oct 2021-April 2022	1-2 swabs per location Weekly	1 swab per location Twice weekly
CO2 monitoring	+	+	-

LTC data

LTC: Study sites

CUBE monitors 22 buildings in Toronto, Ottawa, and Sault Ste. Marie

- 10 LTC homes
- 5 schools and day-cares
- 2 hospitals
- 6 university buildings

Ottawa LTC Results

Barplot showing swab results and segments showing outbreaks.

Ottawa LTC homes

Dotplot showing individual swab results at Ottawa LTCHs.

Other LTCs

Dotplot showing individual swab results at other LTCHs.

LTC Positivity and Outbreak Status

LTC Positivity and Outbreak Status

LTC Positivity and Outbreak Status

Decision-stump with boundary at 0.3 (for example) with on actual data

LTC Model: Bootstrapping

- created a set of 1500 equal-sized resamples of the LTC dataset by sampling with replacement,
- fit a logistic regression model to each resampled dataset,
- then predicted the outbreak status of unseen *out-of-bag* samples

LTC Modelling: Bootstrapped ROC curves

I computed the ROC AUC for each model and plotted their distribution and 95% CIs.

Outbreak ~ swab positivity logistic regression model Bootstrap ROC AUC; B = 1500; lines show mean and 95% CI

1.00 -0.75 sensitivity 0.50 0.25 0.00 -1.00 0.25 0.75 0.00 0.50 1 - specificity

I also plotted the 1500 ROC curves.

Outbreak ~ swab positivity logistic regression r 1500 bootstrapped ROC curves

Hospital surveillance study

Hospital surveillance

Repeat swabbing of rooms with COVID patients at varying distances from their bed over the course of their stay.

PCR quantification cycle as a function of time and distance

Zero cycles indicates a negative PCR result

Points show the cycle value and location of individual observations. Lines connect observations for a single patient and distance over distance (left) or time (right). Blue point-ranges show the mean and SE across all obs. at a given distance (left) or time (right), from bootstrap. Blue line shows the overall trend (Loess fit).

Disclosures and conflicts of interest

- Conflicts of interest
 - ProofDx
 - Editorial board member
- Disclosures

Ottawa LTCs with active cases

