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Research

Systematic on-site testing for SARS-CoV-2 infection among asymptomatic essential workers in Montréal, Canada: a prospective observational and cost-assessment study

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Abstract

Background: Essential workers are at increased risk for SARS-CoV-2 infection. We aimed to estimate the yield, acceptability and cost of systematic workplace-based testing of asymptomatic essential workers for SARS-CoV-2 infection.

Methods: From Jan. 27 to Mar. 12, 2021, we prospectively recruited non–health care essential businesses in Montréal, Canada, through email or telephone contact. Two trained mobile teams, each composed of 2 non–health care professionals, visited businesses. Consenting asymptomatic employees provided saline gargle samples under supervision. Samples were analyzed by means of reverse transcription polymerase chain reaction (RT-PCR). At businesses with outbreaks (≥ 2 participants with a positive result), we retested all participants with a negative result on initial testing. Our primary outcomes were yield (proportion of test results that were positive), acceptability (proportion of participants estimated to be present at the business who agreed to participate) and costs (including training, sample collection and analysis, and communicating results). Our secondary outcome was identification of factors associated with a positive test result on multivariable logistic regression.

Results: Of the 366 businesses contacted, 69 (18.8%) agreed to participate. Nineteen businesses (28%) were manufacturers or suppliers, 12 (17%) were in auto sales or repair, and 11 (16%) were in childcare; the corresponding number of employees was 1225, 242 and 113. The median number of participants per business was 13 (interquartile range [IQR] 8–22). Of an estimated 2348 employees on site, 2128 (90.6%) participated (808 [38.0%] female, median age 48 [IQR 37–57] yr). Of the 2626 tests performed, 53 (2.0%) gave a positive result. Self-reported nonwhite ethnicity (adjusted odds ratio [OR] 3.7, 95% confidence interval [CI] 1.4–9.9) and a negative SARS-CoV-2 test result before the study (adjusted OR 0.4, 95% CI 0.2–0.8) were associated with a positive test result. Five businesses were experiencing an outbreak; at these businesses, 40/917 participants (4.4%) had a positive result on the initial test. We repeated testing for employees with initially negative results at 3 of these businesses over 2–3 weeks: 8/350 participants (2.3%) had a positive result on the second test, and none had a positive result on the third and fourth tests; no employer reported new positive results after our final visit (up to Mar. 26, 2021). At the remaining 64 businesses, 1211 participants were tested once, of whom 5 (0.4%) had a positive result. The per-person RT-PCR cost was $34, and all other costs, $8.67.

Interpretation: On-site saline gargle sampling of essential workers for SARS-CoV-2 testing was acceptable and of modest cost, and appears most useful in the context of outbreaks. This sampling strategy should be evaluated further as a component of efforts to prevent SARS-CoV-2 transmission. **Preprint**: medRxiv — doi:10.1101/2021.05.12.21256956

SARS-CoV-2 infection is a public health emergency. Identification and isolation of infected people is a key component of strategies to prevent and eliminate this infection.[1,2]

Essential workers are at increased risk of acquiring SARS-CoV-2.[3,4] Although guidance is to stay home if symptomatic,[5] infected people may be contagious despite having mild or nonspecific symptoms[6] or no symptoms at all.[7,8] Frequent testing could identify these people in workplaces and prevent further transmission. However, this is not common practice. Instead, people with symptoms are typically encouraged to self-isolate or visit testing centres; this ignores transmission from asymptomatic people and means that employees may need to take time off work, limiting uptake.[9] In addition, the primary method for collecting specimens for SARS-CoV-2 testing is nasopharyngeal swabbing,[10] which must be performed by a health care professional, requires extensive personal protective equipment, and is uncomfortable and

Competing interests: Jonathon Campbell has provided SARS-CoV-2 consulting services to the COVID-19 Immunity Task Force in Canada and the World Bank, unrelated to and outside the submitted work. Cedric Yansouni has provided consulting services to and sat on independent data monitoring committees for Medicago, unrelated to and outside the submitted work. He has served as scientific advisor for the COVID-19 Immunity Task Force, unrelated to and outside the submitted work. No other competing interests were declared.

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expensive.[9,11,12] On-site sampling by means of a more acceptable,[13,14] similarly sensitive[13,15–17] saliva-based method — such as direct saliva collection or saline gargle — that does not require a health care professional would relieve financial and human resource demand and improve feasibility.[15]

We conducted a prospective study in Montréal, Canada, to assess the yield, acceptability and cost of systematic workplace-based collection of saline gargle samples from asymptomatic essential workers for SARS-CoV-2 testing. Our secondary objective was to identify factors associated with a positive test result.

Methods

Study design and setting

This was a prospective observational study combined with a cost assessment. The study took place before widespread SARS-CoV-2 vaccination, from Jan. 27 to Mar. 12, 2021, in Montréal. The primary study location was the borough of Montréal-North, with some participation in immediately adjacent boroughs. Until Jan. 26, 2021, the cumulative SARS-CoV-2 detection rate in Montréal-North was 8088 per 100 000 population, nearly double the cumulative rate in Montréal overall (4445 per 100 000 population).[18] The study immediately followed the peak of the second wave of COVID-19 in Québec. During the study, the provincial weekly SARS-CoV-2 positivity rate via reverse transcription polymerase chain reaction (RT-PCR) testing decreased from 4.0% to 2.7%.[19]

On Dec. 25, 2020, nonessential businesses in Montréal were closed, and a province-wide curfew from 2000 to 0500 was implemented on Jan. 9, 2021. On Feb. 8, 2021 (during the study period), nonessential businesses including personal care services and shopping centres were reopened, and on Feb. 26, 2021, movie theatres, swimming pools and skating rinks were reopened, with some restrictions.[20]

This study is reported according to STROBE[21] guidelines and relevant items in the CHEERS checklist.[22] An earlier version of the manuscript was posted on medRxiv (doi: 10.1101/2021.05.12.21256956).

Participants

Businesses eligible for participation were those deemed essential according to the Quebec government. These included businesses such as grocery, drug and hardware stores, enterprises that sell products necessary for transportation and logistics services, and auto repair businesses.[23] Businesses were contacted to participate via an email from the Chamber of Commerce or a telephone call from a study author (C.D.). For scheduling purposes, businesses interested in participating provided an estimate of the number of employees who would be present on the day of testing.

Eligible employees were those who were at work on the day the study team visited, were at least 18 years old and had not had a positive SARS-CoV-2 test result within the previous 4 weeks. The purpose of the last criterion was to minimize the risk of false-positive results. To verify eligibility, all workers who met the study team were asked "Do you have any symptoms that are unusual or out of the ordinary from how you feel any other day?" (i.e., not associated with pre-existing conditions or their occupation) and whether they had had SARS-CoV-2 testing in the previous 4 weeks.

Procedures

Before initiating the study, we engaged with the mayor's office, business representatives and health authorities of Montréal-North, as well as Montréal Public and Occupational Health, to gain key stakeholder input and refine study priorities and procedures. We recruited 2 mobile sample collection teams consisting of 2 members each. Mobile team members generally had education and experience in a health-related field but were not health care professionals. They received 5 days of training on research, study procedures, and infection-control and infection-prevention measures. Mobile team members were tested weekly during the study for SARS-CoV-2.

On the day of testing, the mobile team set up sampling stations (a table with chairs placed on opposite sides and a Plexiglass divider in the middle) at the business. Stations were sanitized before and after each participant. Mobile team members wore gloves (changed between participants) and at least one 3-layer surgical mask but did not wear face shields, eye protection or gowns. All participants had to wear masks (cloth or surgical) and sanitize their hands.

Eligible participants were introduced to the study and provided signed informed consent, then completed a questionnaire. Under the supervision of a mobile team member, each participant provided a saline gargle sample to be tested for SARS-CoV-2. Participants placed 5 mL of saline solution in their mouth, swished the solution for 5 seconds and gargled the solution for 5 seconds, then repeated the procedure; all liquid was placed in a tube and sealed (Appendix 1, Sampling protocol, available at www.cmajopen.ca/content/10/2/E409/suppl/DC1). Participants then sanitized their hands and returned to work. Sample tubes were sanitized and packaged for transport to the laboratory.

Samples were analyzed following RT-PCR protocols, the reference standard for SARS-CoV-2 detection,[10,13,24] by OPTILAB, the laboratory servicing the McGill University Health Centre. Results were transmitted 4–24 hours later to the study team, who then notified participants immediately. Participants with a negative test result were notified by email or text message. Participants with a positive result were notified by telephone, asked to isolate at home (and not go to work) and provided information on social support available to them; subsequent management was done by Montréal Public and Occupational Health.

If 2 or more participants with a positive test result were identified in a workplace, this met the definition of an outbreak,[25] and the lead author (J.R.C.) notified Montréal Public and Occupational Health. Businesses were not closed because of outbreaks, and outbreaks were managed on a case-by-case basis by Montréal Public and Occupational Health. We hypothesized that returning to these businesses to repeat testing might help to end outbreaks. The lead author (J.R.C.) contacted the business to offer to return within 4–5 days to retest all employees with a negative test result and to test those who had not been tested. We selected the interval of 4–5 days based on the incubation period of SARS-CoV-2.[26] Subsequently, we offered a third round of testing 4–5 days after our second visit, and a fourth round of testing 14–21 days after our third visit. Montréal Occupational Health referred an additional 3 businesses experiencing the onset of an outbreak to the study team. We followed identical procedures with these businesses.

Data sources

We collected participant data through an electronic questionnaire that was developed by the study team. The questionnaire elicited information on demographic and clinical characteristics, previous SARS-CoV-2 testing, previous illnesses and current symptoms (Appendix 1, Participant questionnaire and Table S1). The questionnaire was administered on shared tablets that were disinfected between uses. If participants preferred not to use a tablet, a paper copy of the questionnaire was provided. We reviewed the participant's responses after the visit.

Outcome measures

Our primary outcomes were yield, acceptability and cost of workplace-based collection of saline gargle samples from asymptomatic essential workers for SARS-CoV-2 testing. We defined yield as the proportion of test results that were positive during the study, and acceptability as the proportion of participants estimated to be present at the business who agreed to participate in the study.

We reported costs per participant tested, assuming that a 2-person mobile team can visit two 50-person businesses each day. We estimated the unit costs of training, scheduling, sample collection, sample transport, RT-PCR and contacting participants, following our previously published conceptual framework.[27] We used a health care system perspective and reported costs in 2021 Canadian dollars. We considered only costs that would be incurred outside of a research study using a microcosting approach (Appendix 1, Table S2). We assumed that one 2-person mobile team can collect samples from 500 people per week, and that training would need to be repeated annually and capital purchases replaced annually — total costs for these were prorated over a year (i.e., divided by 26 000 people sampled). To estimate costs of personnel time, we used questionnaires asking study team members to estimate their time on specific tasks. We assumed a coordinator wage of $30/hour, mobile team wage of $23/hour and administrative support wage of $20/hour. For RT-PCR costs, we used the reimbursement cost for a sample undergoing laboratory RT-PCR in Quebec.[28]

Our secondary outcome was the identification of factors associated with a positive test result. We considered the following factors:

- Participant age (continuous), sex (male v. female) and self-reported ethnicity (white v. nonwhite), as these characteristics may be associated with SARS-CoV-2 infection[4,29,30]
- Health factors (any of hypertension, diabetes, respiratory condition, heart disease or other health condition v. not) and smoking history (current or previous smoker v. never smoker), as they may modulate susceptibility to infection and adverse outcomes[31–33]
- How participants were feeling on the day of testing, as reported on the questionnaire ("fine" v. "not my best today"), as symptomatic people are more likely than asymptomatic people to have SARS-CoV-2 infection[7]
- Previous testing history (never previously tested v. previously tested and always negative v. previously tested and positive), as this may be a proxy for other health behaviours that modulate risk of infection
- Business size (1–50 participants v. ≥ 51 participants), as this may affect the likelihood of transmission and, thus, risk of infection.[34]

Statistical analysis

Based on previous reports from Calgary,[35] we determined that SARS-CoV-2 prevalence might be 5% among essential workers in Montréal-North. We estimated the number of essential workers in Montréal-North based on previous work.[27] Considering finite sample size, and using a binomial estimator, an intraclass correlation coefficient of 0.3 between businesses and an absolute precision of ±2% around the 5% target,[36] we estimated that 2589 participants would be required to estimate a 5% prevalence with a 95% confidence interval of 3%–7% (further details are provided in Appendix 1, Sample size). We estimated the yield of testing overall (i.e., prevalence) and among various subgroups.

We performed logistic regression using generalized linear mixed-models to estimate adjusted odds ratios (ORs) and 95% CIs for potential factors associated with a positive result.[37] We treated each business and sector as a random effect, with businesses nested within sectors. To deal with quasicomplete separation associated with some fixed effects, we used weakly informative priors.[38] For businesses experiencing an outbreak and where repeat testing was performed, we described the investigations and plotted the evolution of the outbreaks over time.

In sensitivity analyses, we also considered the costs of visiting eight 5-person businesses, four 20-person businesses, and one 120-person business each day. Further details are given in Appendix 1, Cost assessment details.

Analysis was done in R (version 4.0.3) with base packages or package blme (version 1.0–5).

Ethics approval

This study was approved by the Research Institute of the McGill University Health Centre Research Ethics Board (2021–7057); all participants gave explicit, informed consent.

Results

Of the 366 businesses contacted, 69 (18.8%) agreed to participate and were visited. Businesses in the manufacturing or supplier or the childcare sector were more likely to participate than not, whereas retail businesses were more likely to not participate (Appendix 1, Table S3). Of the 2348 eligible employees estimated on site, 2138 (91.0%) met with the study team, and 2128 (90.6%) consented to participate (Figure 1).

The median number of participants per business was 13 (interquartile range 8–22). Most businesses (61 [88%]) had 50 or fewer participants (Table 1). Of the 2128 participants, 808 (38.0%) were female, and the median age was 48 (interquartile range 37–57) years (Table 2). Most participants (1225 [57.6%]) worked in the manufacturing or supplier sector.

When asked by research staff, no participant mentioned "unusual" or "out of the ordinary" symptoms. However, 30 participants (1.4%) reported not feeling their best on the study questionnaire. Almost half of participants (973 [45.7%]) had been tested for SARS-CoV-2 at some point before the study: 882/2128 (41.4%) never had a positive result, and 91/2128 (4.3%) had a positive result more than 4 weeks before study enrolment (Table 2).

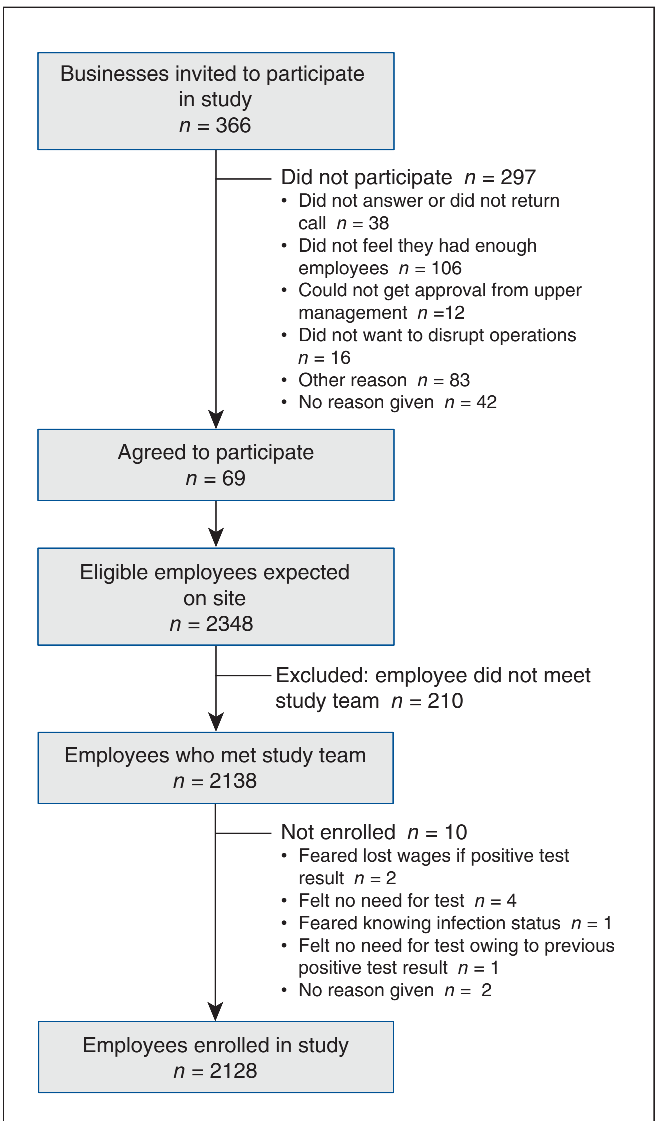


Figure 1: Flow diagram showing selection of businesses and participants.

Yield of systematic testing

We performed 2626 SARS-CoV-2 tests among the participants, of which 53 (2.0%) gave a positive result. Forty-five participants (2.1%) at 8 businesses had a positive result on their first test. We performed subsequent testing at 3 businesses experiencing an outbreak. An additional 8/350 participants (2.3%) had a positive result on their second test after testing negative on their first test. None of the 121 and 27 participants who were tested a third and fourth time, respectively, tested positive (Appendix 1, Table S4). No mobile team member tested positive during the study.

Of the 53 participants with a positive result, 43 (81%) were at 3 different manufacturing and supplier businesses, 6 (11%) were at 1 meat processing facility, 3 (6%) were at 3 different childcare enterprises, and 1 (2%) was at a grocery store. Forty-nine (92%) of the 53 worked at businesses with more than 50 participants.

Five of the 69 businesses visited were experiencing an outbreak (i.e., 2 or more participants in a single business had positive test results). At these 5 businesses, 917 participants were tested at least once, of whom 40 (4.4%) had a positive result on initial testing. At the 64 businesses not experiencing an outbreak, 5 (0.4%) of 1211 participants had a positive test result. These infections occurred in 3 childcare enterprises, 1 manufacturing and supplier business, and 1 grocery store.

Costs associated with systematic testing

The total cost per person tested was $42.67, of which $34 (80%) was for the RT-PCR test (Table 3). In sensitivity analyses, non–RT-PCR costs were lower at larger businesses

Table 1: Characteristics of included businesses in Montréal-North

Characteristic	No. (%) of businesses *n* = 69	No. (%) of participants *n* = 2128
Business sector		
Manufacturing/supplier	19 (27.5)	1225 (57.6)
Auto sales and repair	12 (17.4)	242 (11.4)
Childcare	11 (15.9)	113 (5.3)
Public services	8 (11.6)	144 (6.8)
Grocery	6 (8.7)	100 (4.7)
Retail	6 (8.7)	84 (3.9)
Construction	4 (5.8)	28 (1.3)
Meat processing	2 (2.9)	183 (8.6)
Legal	1 (1.4)	9 (0.4)
Size, no. of participants		
1–5	11 (15.9)	44 (2.1)
6–10	14 (20.3)	113 (5.3)
11–20	26 (37.7)	388 (18.2)
21–50	10 (14.5)	350 (16.4)
≥ 51	8 (11.6)	1233 (57.9)

Table 2: Characteristics of participants

Characteristic	Test result; no. (%) of participants*		
	Overall *n* = 2128	Positive *n* = 53	Negative *n* = 2075
Age, median (IQR), yr	48 (37–57)	49 (40–58)	48 (37–57)
Sex			
Female	808 (38.0)	9 (17.0)	799 (38.5)
Male	1320 (62.0)	44 (83.0)	1276 (61.5)
Self-reported ethnicity			
White	926 (43.5)	4 (7.5)	922 (44.4)
Asian	444 (20.9)	17 (32.1)	427 (20.6)
Black	295 (13.9)	21 (39.6)	274 (13.2)
Hispanic	204 (9.6)	6 (11.3)	198 (9.5)
Indigenous	4 (0.2)	0 (0.0)	4 (0.2)
Mixed	17 (0.8)	0 (0.0)	17 (0.8)
Other/not disclosed	238 (11.2)	5 (9.4)	233 (11.2)
Employment status			
Full-time	2018 (94.8)	51 (96.2)	1967 (94.8)
Part-time or occasional	110 (5.2)	2 (3.8)	108 (5.2)
Reported health factor			
Any†	447 (21.0)	8 (15.1)	439 (21.2)
Hypertension	214 (10.0)	4 (7.5)	210 (10.1)
Diabetes	151 (7.1)	4 (7.5)	147 (7.1)
Chronic respiratory condition	64 (3.0)	1 (1.9)	63 (3.0)
Heart disease	31 (1.4)	0 (0.0)	31 (1.5)
Other	99 (4.6)	1 (1.9)	98 (4.7)
None	1681 (79.0)	45 (85.)	1636 (78.8)
Reported smoking			
Never smoker	1668 (78.4)	46 (86.8)	1622 (78.2)
Current smoker	331 (15.6)	5 (9.4)	326 (15.7)
Former smoker	129 (6.1)	2 (3.8)	127 (6.1)
Previous SARS-CoV-2 test history‡			
Never tested	1155 (54.3)	42 (79.2)	1113 (53.6)
All test results negative	882 (41.4)	9 (17.0)	873 (42.1)
Any test result positive	91 (4.3)	2 (3.8)	89 (4.3)
Feeling on day of testing§			
"Fine, same as any other day"	2098 (98.6)	51 (96.2)	2047 (98.6)
"Not my best today"	30 (1.4)	2 (3.8)	28 (1.3)
Business sector			
Manufacturing/supplier	1225 (57.6)	43 (81.1)	1182 (57.0)
Meat processing	183 (8.6)	6 (11.3)	177 (8.5)
Childcare	113 (5.3)	3 (5.7)	110 (5.3)
Other	607 (28.5)	1 (1.9)	606 (29.2)
Business size, no. of participants			
1–5	44 (2.1)	1 (1.9)	43 (2.1)
6–10	113 (5.3)	2 (3.8)	111 (5.3)
11–20	388 (18.2)	1 (1.9)	387 (18.6)
21–50	350 (16.4)	0 (0.0)	350 (16.9)
≥ 51	1233 (57.9)	49 (92.4)	1184 (57.1)

Note: IQR = interquartile range.
*Except where noted otherwise.
†Participants could have more than 1 health factor.
‡Before enrolment in the study.
§As reported on patient questionnaire.

Table 3: Cost per person tested of training, scheduling, saline gargle collection, sample transport and contacting of participants, assuming two 50-person businesses are visited per day by 2 mobile team members

Cost	Cost per person tested, $	Details
Laboratory	34.00	Reimbursement cost for RT-PCR to detect SARS-CoV-2
Nonlaboratory	8.67	
Training mobile team	0.04	
Coordinator and mobile team personnel	0.03	Based on 2 d of training*
Materials and refreshments	0.01	Includes meals, materials for sample collection, and sanitizing and personal protective equipment†
Administrative personnel to schedule businesses	0.80	Based on 2 h per business‡
Sample collection	5.62	
Mobile team personnel	2.99	Based on 45 min to set up and tear down at each business and 6 min per person tested‡
Sanitizing materials	0.33	Includes rags, paper towels, disinfectant and hand sanitizer†
Personal protective equipment	0.38	Includes 4 masks per day and 2 gloves per participant†
Sample collection materials	1.74	Includes a sample tube, a 5-mL saline ampoule and 2 biohazard bags†
Capital purchases	0.18	Includes items such as chairs, tables, trash bins, Plexiglass dividers, stationery, tablets for data collection, storage bins, dollies and coolers†
Sample transport	0.54	
Mobile team personnel	0.19	Assuming 30 min to drop off samples and 10 min driving between businesses‡
Vehicle and fuel	0.35	Assuming 60 km driven per day‡
Administrative personnel to communicate results	1.67	Based on 5 min per result on average‡
Total	42.67	

Note: RT-PCR = reverse transcription polymerase chain reaction.
*Estimated during study for nonresearch training days.
†See Appendix 1, Table S2, for more details.
‡Estimated during study.

($7.62) and higher at smaller businesses ($24.33 for those with 5 employees, $11.28 for those with 20 employees). Further details are provided in Appendix 1, Table S5.

Factors associated with a positive SARS-CoV-2 test result

Few factors were associated with a positive test result in adjusted analyses. A positive result was more likely among participants who self-identified as nonwhite (adjusted OR 3.7, 95% CI 1.4–9.9) and less likely in participants who had had at least 1 negative SARS-CoV-2 test result before study enrolment (adjusted OR 0.4, 95% CI 0.2–0.8) (Table 4). Unadjusted estimates are given in Appendix 1, Table S6.

Details of outbreaks

Two SARS-CoV-2 infection outbreaks, in businesses A and B, were discovered by the study team. In both instances, the employer then informed us that multiple symptomatic infections had been detected 3–4 weeks before our visit. Three outbreaks, in businesses C, D and E, were referred by public health.

Over the course of 4 visits to business A (manufacturing and supplier sector), test positivity decreased steadily, reaching 0% on the final visit (Figure 2A). There were 4/39 (10%) and 1/68 (2%) conversions (negative to positive) on the second and third visit, respectively. Similar trends were observed at business B (manufacturing and supplier sector) (Figure 2B), where test positivity declined to 0% by the third round of testing; 3/65 conversions (5%) were detected on the second visit. Acceptance of repeat testing was 100% at business A and 86% at business B. As of Mar. 26, 2021 (4 wk after our final visit to business A and 2 wk after our final visit to business B), no new infections were reported.

On initial testing at business C (manufacturing and supplier sector), 6/113 participants (5.3%) had a positive result, compared to 4/463 (0.9%) on our second visit and 0/131 on our final visit (Appendix 1, Figure S1); the rate of retesting acceptance was 100%. As of Mar. 26, 2021 (2 wk after our final visit), no new infections were reported.

Businesses D and E were in the meat processing sector. None of the 47 participants at business D had a positive result

Table 4: Logistic regression results for factors potentially associated with ever testing positive*

Factor	No. of participants *n* = 2128	No. (%) of tests positive	Adjusted OR (95% CI)†
Age (per 1-yr increase)	–	–	1.0 (0.98–1.0)
Sex			
Female	808	9 (1.1)	1.0 (reference)
Male	1320	44 (3.3)	2.2 (0.9–5.3)
Self-reported ethnicity			
White	926	4 (0.4)	1.0 (reference)
Nonwhite	1202	49 (4.1)	3.7 (1.4–9.9)
Health factor‡			
None reported	1681	45 (2.7)	1.0 (reference)
Any reported	447	8 (1.8)	0.7 (0.3–1.5)
Smoking history			
Never smoker	1668	46 (2.8)	1.0 (reference)
Current or previous smoker	460	7 (1.5)	0.7 (0.3–1.5)
Feeling on day of testing			
"Fine, same as any other day"	2098	51 (2.4)	1.0 (reference)
"Not my best today"	30	2 (6.7)	3.5 (0.7–16.9)
Previous SARS-CoV-2 test history			
Never tested	1155	42 (3.6)	1.0 (reference)
All test results negative	882	9 (1.0)	0.4 (0.2–0.8)
Any test result positive	91	2 (2.2)	0.7 (0.2–3.0)
Business size, no. of participants			
1–50	895	4 (0.4)	1.0 (reference)
≥ 51	1233	49 (4.0)	7.9 (0.8–75.3)

Note: CI = confidence interval, OR = odds ratio.
*The model accounts for clustering by business and sector.
†Models are adjusted for all factors included in the table.
‡Includes hypertension, diabetes, chronic respiratory conditions (e.g., asthma), heart disease or participant-reported condition.

on initial testing, so we did not return for further testing. We tested 136 participants at business E, of whom 6 (4.4%) had a positive result. We were unable to schedule a return visit before the end of the study; as of Mar. 26, 2021 (3 wk after our visit), an additional 2 people had developed symptoms and had a positive SARS-CoV-2 test result.

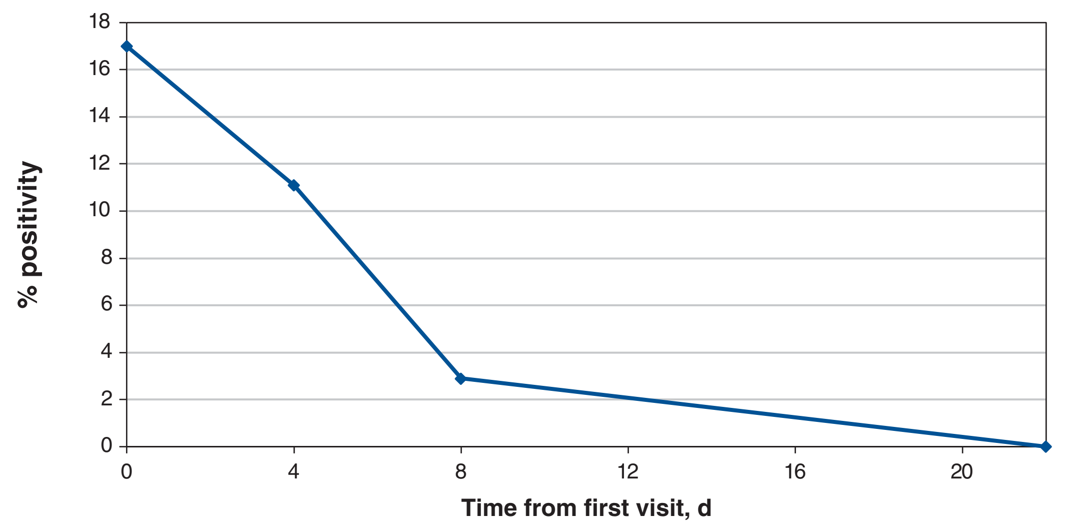
Interpretation

We found that systematic on-site sampling of asymptomatic essential workers with saline gargle for SARS-CoV-2 testing was acceptable and of modest cost. The yield of a first test among employees at businesses experiencing an outbreak was 11-fold higher than that at businesses not experiencing an outbreak (4.4% v. 0.4%). Among businesses experiencing an outbreak, repeated testing of those with a negative test result over a period of 2–3 weeks detected new infections and, together with isolation of people with a positive test result, appeared to help stop transmission; this benefit persisted for at least 2 weeks after our last visit.

Essential workers who self-identified as nonwhite had significantly higher odds of testing positive for SARS-CoV-2 than those who self-identified as white. This has been found in other studies[4,39,40] and may reflect differences in socioeconomic situations, as well as trust in or access to health care services. Reducing such inequities should be a priority,[41,42] with further research necessary to identify underlying causes and effective solutions.

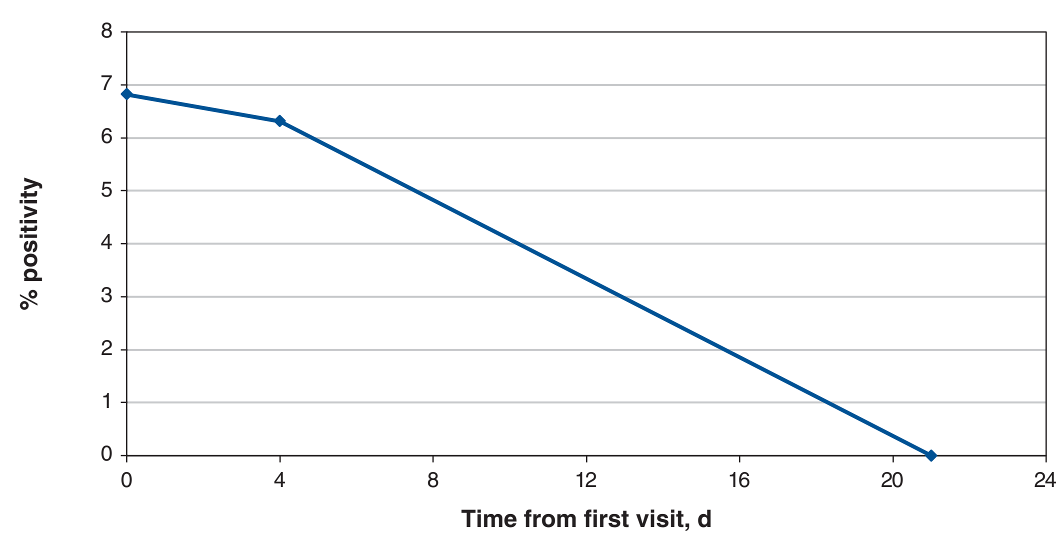
Workplaces have been a substantial source of transmission during the COVID-19 pandemic.[18,43] Nonpharmaceutical interventions, such as improved ventilation and appropriate personal protective equipment, are essential to mitigate transmission.[44,45] Current methods of infection detection rely largely on presentation of symptomatic workers for testing. However, we observed ongoing transmission among asymptomatic workers several weeks after symptomatic infections had been detected. This suggests that more proactive testing strategies are required. With an estimated 2.6 million essential workers in Canada at high risk for exposure to SARS-CoV-2,[27] testing programs will need to prioritize who and where to test.

A



Positivity rate	Visit 1	Visit 2	Visit 3	Visit 4
First test	9/53 (17%)	5/42 (12%)	1/2 (50%)	0/1 (0%)
Second test	–	4/39 (10%)	1/36 (3%)	0/3 (0%)
Third test	–	–	0/32 (0%)	0/28 (0%)
Fourth test	–	–	–	0/27 (0%)
Overall	9/53 (17%)	9/81 (11%)	2/70 (3%)	0/59 (0%)

B



Positivity rate	Visit 1	Visit 2	Visit 3
First test	6/88 (7%)	3/30 (10%)	0/16 (0%)
Second test	–	3/65 (5%)	0/18 (0%)
Third test	–	–	0/46 (0%)
Overall	6/88 (7%)	6/95 (6%)	0/80 (0%)

Figure 2: Evolution of SARS-CoV-2 infection outbreaks at businesses A (A) and B (B) (both manufacturing and supplier sector).

Benefits of testing to curb transmission appear greatest when testing is used repeatedly in businesses with a few infections. Repeat testing during outbreaks in long-term care facilities has been recommended by the United States Centers for Disease Control and Prevention since May 2020[46] and was suggested by a task force convened by the Chief Science Advisor of Canada in summer 2020.[47] Repeat testing during outbreaks has been performed in studies in long-term care[48–50] and other congregate settings,[51,52] with additional infections detected in participants with initially negative results. Those findings are similar to ours in business settings, although our findings require confirmation in future studies, particularly in the context of widespread vaccination.

Repeat testing at businesses experiencing outbreaks serves multiple purposes. Most important, testing every 4–5 days at the onset of an outbreak identifies people who may have been infected recently but had a negative test result initially.[26] Repeat visits also permit testing of employees who could not be tested during previous visits. A final test a few weeks later can confirm whether any new infections have arisen from the initial cluster.[26] Compared to costs to the businesses of lost production and to the workers of lost wages associated with shuttering businesses, the costs of repeated systematic testing are low, and this strategy seems to be a substantially better approach.[53]

Saline gargle for RT-PCR is an attractive specimen for on-site sampling.[13] Gargle samples have similar sensitivity to nasopharyngeal swabs,[13,16,17] can be self-collected without the presence of a health care professional and are stable at room temperature.[13] In addition, this sampling method was highly acceptable in our study, as shown by the high participation rates on initial and repeat testing. Sample materials are inexpensive, and all nonlaboratory costs involved in a testing program should be less than $10 per person. Although RT-PCR costs are not trivial, they could be reduced substantially through sample pooling algorithms.[27,54] Results can potentially be available within hours, but, in practice, laboratory turnaround times may cause major delays in obtaining results[55] if laboratory capacity is inadequate. Developing laboratory infrastructure further or expanding the laboratory network to accredited private laboratories may alleviate these limitations.

Alternatively, developing test capacity for workplace testing outside the laboratory through antigen-based rapid tests appears promising.[56,57] These tests are done at the point of care and give same-day results. However, rapid tests have lower sensitivity and specificity than RT-PCR.[58] Their lower sensitivity may be overcome by more frequent testing,[59] but the potential for false-positive results — from the device itself, improper manipulation or user interpretation — may necessitate confirmation by nucleic acid amplification tests in certain epidemiologic settings. Major barriers to their uptake have been logistic limitations and a lack of clear communication surrounding in which cases their use is acceptable. Access to rapid tests for self-testing became widely available in Canada only in late 2021/early 2022. In a subsequent prospective study, we found that essential workers could perform self-testing adequately using manufacturer-included instructions, but that the interpretation of test results was significantly improved after modified instructions that emphasized key processes were implemented.[60] The cost of the tests themselves is about $5,[61] but other costs associated with testing are uncertain, and the need for RT-PCR confirmation will vary by epidemiologic setting and government policy.

Limitations

Businesses included in this study were those willing to participate. Although we targeted essential businesses of all types, the acceptance rate may limit generalizability and have introduced bias; however, this is unlikely to influence our findings on the acceptability of the sampling method. The observed prevalence of SARS-CoV-2 infection was lower than expected, which may have affected the precision in our estimate. Three businesses included in this study were referred to the study team by public health; however, the positivity rates among tests done at those businesses were similar to those at other businesses.

We did not do sequencing to confirm transmission between participants. However, the identification of new cases of conversion among employees at intervals of 4–5 days strongly suggests ongoing transmission. We did not consider downstream costs or inefficiencies such as "dead time" associated with waiting between employees in our cost analysis, which may have led to an underestimation of costs. Finally, this study took place before widespread vaccination. However, evidence of transmission from and between vaccinated people[62,63] suggests that our findings on the potential benefits of repeated testing in outbreaks should remain relevant.

Conclusion

Systematic on-site saline gargle sampling of asymptomatic essential workers for SARS-CoV-2 infection was an acceptable method to detect workplace infections. Use of this method spares health care professionals for other tasks. The yield of systematic testing was greatest among businesses experiencing outbreaks. We believe that this sampling strategy should be evaluated further as a component of efforts to prevent SARS-CoV-2 transmission.

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