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Research Brief

Can testing the environment for severe acute respiratory coronavirus virus 2 (SARS-CoV-2) be a signal for coronavirus disease 2019 (COVID-19) cases among nursing home staff?

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Prior to widespread COVID-19 vaccination, nursing homes were required to perform comprehensive weekly testing of staff.¹ After the vaccine became available, testing became symptom-based for vaccinated staff despite continued waves of different severe acute respiratory coronavirus virus 2 (SARS-CoV-2) variants. Nursing homes need pragmatic, affordable strategies to identify SARS-CoV-2-positive staff because financial and job-related pressures drive reluctance to disclose mild symptoms.^{2–4} We sought to determine whether positive environmental samples for SARS-CoV-2 could serve as trigger for comprehensive staff testing in lieu of weekly testing of all staff.

Methods

We conducted a cross-sectional study to assess the correlation between high-touch object and staff SARS-CoV-2 test positivity in Orange County, California, nursing homes. Environmental sampling was classified as non-human-subjects research and was conducted through our role as the county's nursing home COVID-19 prevention team.⁵

We performed 35 environmental sampling sweeps across 21 nursing homes from June 16, 2020, through February 10, 2021. In each sweep, we sampled up to 24 objects in areas where staff were likely to unmask: breakrooms (N = 14: tables and chairs, microwave and refrigerator handles, and doorknobs), nursing stations (N = 6: computers and phones, time clock, countertop, and chairs), and entryways (N = 4: check-in table, doorbell and doorknob, and front-desk countertop).

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Sampling occurred after daily room use by staff, but prior to daily routine cleaning. Objects were sampled using premoistened flocked swabs (Copan Diagnostics, Murrieta, CA), transported in DNA/RNA Shield media (Zymo Research, Irvine, CA) and processed within 12 hours for SARS-CoV-2 using real-time reverse-transcriptase polymerase chain reaction (RT-PCR; StepOnePlus Real-Time PCR System, Applied Biosystems, Foster City, CA) with a limit of detection of 1 copy per milliliter. In the first half of the study, object swabs were processed individually; in the second half of the study, similar objects were pooled by room-type. Samples were classified as positive when cycle thresholds for both SARS-CoV-2 spike protein and nucleocapsid phosphoprotein genes were <40.

We used data from mandatory weekly COVID-19 testing to determine total positive staff and total staff tested the week of and prior to environmental sampling. We evaluated the concordance between the presence of any positive object and any positive staff using the Cohen κ , and we calculated the positive and negative predictive values (PPVs and NPVs) of environmental sweeps for staff positivity. We calculated the attributable capture of positive staff as total positive staff in sweeps with positive objects divided by total positive staff across all sweeps. We evaluated the association between percent staff positivity and percent object positivity by room type in linear regression models clustering by nursing home.

Results

Overall, swabs from 636 objects and 4,621 staff were processed for SARS-CoV-2 PCR testing, with a crude positivity rate of 14.8% for objects and 3.2% for staff. Among 35 sweeps, 17 (48.6%) had positive objects and 24 (68.6%) had positive staff in the same or prior week. Among positive environmental sweeps, the mean number of positive objects was 5.2 (32.8%; range, 16.7%–83.3%) and the mean number of positive staff was 6.5 (6.9%; range, 1.2%–22.5%). Object

Fig. 1. Performance of environmental sampling of high-touch objects for SARS-CoV-2 as a mechanism to detect infections among nursing home staff. (a) Attributable capture was calculated as the total number of COVID-19 cases among staff in sweeps where environmental SARS-CoV-2 contamination was detected divided by the total number of staff cases across all sweeps. (b) Sampled objects included microwave and refrigerator handles, vending machine buttons, doorknobs, tables, and chairs. (c) Sampled objects included staff check-in table, entrance door handle, and front-desk countertop. (d) Sampled objects included computers, phones, employee timeclock, countertop, and chairs.

| | All Rooms | Breakroom ^b | Entryway ^c | Nursing Station ^d | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
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| Positive Predictive Value (PPV) | 100% | 100% | 100% | 100% | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Negative Predictive Value (NPV) | 61% | 55% | 46% | 44% | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Attributable Capture of Staff Cases^a | 76% | 68% | 51% | 53% | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 2x2 Contingency Table <small>Staff and Environmental SARS-CoV-2 Positivity Across 35 Nursing Home Sweeps</small> | <table border="1"> <thead> <tr> <th colspan="2"></th> <th colspan="2">Staff</th> </tr> <tr> <th colspan="2"></th> <th>+</th> <th>-</th> </tr> </thead> <tbody> <tr> <th rowspan="2">Env</th> <th>+</th> <td>17</td> <td>0</td> </tr> <tr> <th>-</th> <td>7</td> <td>11</td> </tr> </tbody> </table> | | | Staff | | | | + | - | Env | + | 17 | 0 | - | 7 | 11 | <table border="1"> <thead> <tr> <th colspan="2"></th> <th colspan="2">Staff</th> </tr> <tr> <th colspan="2"></th> <th>+</th> <th>-</th> </tr> </thead> <tbody> <tr> <th rowspan="2">Env</th> <th>+</th> <td>15</td> <td>0</td> </tr> <tr> <th>-</th> <td>9</td> <td>11</td> </tr> </tbody> </table> | | | Staff | | | | + | - | Env | + | 15 | 0 | - | 9 | 11 | <table border="1"> <thead> <tr> <th colspan="2"></th> <th colspan="2">Staff</th> </tr> <tr> <th colspan="2"></th> <th>+</th> <th>-</th> </tr> </thead> <tbody> <tr> <th rowspan="2">Env</th> <th>+</th> <td>11</td> <td>0</td> </tr> <tr> <th>-</th> <td>13</td> <td>11</td> </tr> </tbody> </table> | | | Staff | | | | + | - | Env | + | 11 | 0 | - | 13 | 11 | <table border="1"> <thead> <tr> <th colspan="2"></th> <th colspan="2">Staff</th> </tr> <tr> <th colspan="2"></th> <th>+</th> <th>-</th> </tr> </thead> <tbody> <tr> <th rowspan="2">Env</th> <th>+</th> <td>10</td> <td>0</td> </tr> <tr> <th>-</th> <td>14</td> <td>11</td> </tr> </tbody> </table> | | | Staff | | | | + | - | Env | + | 10 | 0 | - | 14 | 11 |
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positivity by room type is shown in Supplementary Table 1 (online).

The PPV of object sampling as an indicator of positive staff was 100% for every room type (Fig. 1). Overall, NPV was 61% and the Cohen κ was 0.6. Breakroom samples were the strongest indicator of any staff cases with an attributable capture of 99 (67.8%) of 146 staff cases. Overall, attributable capture of positive staff across all objects was 111 (76.0%) of 146. In linear regression models (Supplementary Table 2 online), each percentage increase in room-specific object positivity was associated with an increase in staff positivity in entryways (7.2% increased staff positivity; $P = .005$) and nursing stations (5.7% increased staff positivity; $P = .05$).

A 100-bed nursing home with 200 full- and part-time staff spends \$4,000 in antigen tests (\$20 per test) or \$20,000 in PCR tests (\$100 per test) in contrast to \$300 for 3 pooled PCR tests of breakroom, entryway, and nursing-station objects. For antigen testing, the cost savings occur if 1 in 13 weekly samples are negative, or 1 in 66 for PCR, because that would obviate the need for comprehensive staff testing.

Discussion

Effective pandemic response in nursing homes requires cost-effective means for identifying infected staff who often face economic and job-related pressures that may influence their willingness to report potential symptoms.^{2–4} The high cost of weekly comprehensive testing and fatigue of nursing home staff on being swabbed raises interest in alternative methods that can signal when staff testing needs to be undertaken.

SARS-CoV-2 fomite contamination in nursing home rooms where staff commonly remove masks was significantly associated with recent staff positivity. The fact that breakroom contamination had the strongest association with staff positivity likely reflects prolonged removal of masks for eating. Notably, every time environmental contamination was found, there were concurrent positive staff cases with a PPV of 100%, suggesting that any object positivity could signal the need for staff testing. Moreover, negative object samples could obviate the need for staff testing, saving nursing homes thousands of dollars.

This study had several limitations. Virus detected by PCR may not be viable or transmissible. Yet, SARS-CoV-2 is shed by infected persons for ~1 week and remains viable on common nonporous surfaces for ~72 hours.⁶ Although we did not evaluate different time intervals, the correlation between positive objects and positive staff the week of or prior to environmental sampling suggests recent contamination. Our NPV may have been improved by

sampling more objects. Differences in the time since last cleaning may explain instances when contamination was not detected despite having positive staff, since that time reflects opportunity that an infected person frequented the sampled area. Although we sampled staff-specific areas, virus may have been transferred to objects via contaminated hands of staff that cared for SARS-CoV-2-positive residents.

Our findings suggest that environmental sampling in nursing homes may offer a cost-effective way to trigger comprehensive COVID-19 testing of staff, especially in the absence of testing mandates.

Supplementary material. To view supplementary material for this article, please visit <https://doi.org/10.1017/ice.2022.303>

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Conflicts of interest. All authors report no conflicts of interest relevant to this article.

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