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## Concise Communication

# Coronavirus disease 2019 (COVID-19) vaccine breakthrough infections among healthcare personnel, December 2020–April 2021

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**Abstract**

Coronavirus disease 2019 (COVID-19) vaccine effectiveness in the early months of vaccine availability was high among healthcare personnel (HCP) at 88.3% for 2-doses. Among those testing positive for severe acute respiratory coronavirus virus 2 (SARS-CoV-2), those with breakthrough infection after vaccination were more likely to have had a non–work-related SARS-CoV-2 exposure compared to unvaccinated HCP.

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Healthcare personnel (HCP) are at risk for severe acute respiratory coronavirus virus 2 (SARS-CoV-2) exposure in work and home settings.[1,2] In this study, we sought to determine coronavirus disease 2019 (COVID-19) vaccine effectiveness. We also describe differences among those positive for SARS-CoV-2 by vaccination status among employees of a large academic medical center and affiliated multihospital healthcare system using real-world operational data.

## Methods

We utilized records from the Washington University School of Medicine (WU) and BJC HealthCare System (BJC) COVID-19 Occupational Health Call Center from December 28, 2020, to April 29, 2021, for employees aged ≥18 years who called due to SARS-CoV-2 exposure and/or COVID-19 symptoms. WU and BJC employ >40,000 people. The study start date was chosen as December 28, 2020, which was 14 days after COVID-19 vaccine became available at our institution. This study was approved by the WU Human Research Protection Office with a waiver of informed consent.

Information collected during the calls included demographics, employment details, SARS-CoV-2 exposure information, SARS-CoV-2 testing history, symptoms, and COVID-19 vaccine information. For calls resulting in a nasopharyngeal SARS-CoV-2 polymerase chain reaction (PCR) test, results were linked to the associated call. For this analysis, we grouped repeat calls from an employee within 3 days as a single episode.

COVID-19 vaccine information was self-reported; we categorized employees into 3 mutually exclusive groups. Employees vaccinated with 2 doses received 2 appropriately spaced doses (ie, ≥17 days apart) of COVID-19 vaccine ≥14 days before the call date. Employees vaccinated with 1 dose had received 1 COVID-19 vaccine dose ≥14 days before the call date and had not yet received a second dose by the date of the call (or had received a second dose 0–13 days before the call date). Unvaccinated employees had not received any doses of a COVID-19 vaccine before the call date.

We restricted our study to calls with an associated SARS-CoV-2 PCR test ordered and results obtained ≤7 days after the call. We excluded calls with inconsistent reported timing including (1) calls during which an employee reported a SARS-CoV-2 exposure after the call date; (2) calls in which an employee reported symptom onset as >14 days before or >7 days after the call date; and (3) calls in which an employee reported receiving a vaccine before December 14, 2020, because we could not determine whether the COVID-19 vaccine was through a clinical trial or an incorrect date. We also excluded calls from those who reported being vaccinated 0–13 days before the call date so that the unvaccinated group for comparison had not received any vaccine. Finally, we excluded calls from employees who received 2 doses <17 days apart because this deviated from the recommended administration schedule.

Vaccine effectiveness estimates were calculated with the use of relative risk (RR) and 95% confidence intervals from generalized estimating equation (GEE) models to account for multiple calls for some employees. Vaccine effectiveness comparing those who received 1 and 2 doses to unvaccinated individuals, respectively, was calculated as $(1 - RR) \times 100\%$.

We used *P* values generated from GEE models clustered by employee to examine the association between demographics, employee details, SARS-CoV-2 exposure history, and symptoms

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**Table 1.** Vaccine Effectiveness Against SARS-CoV-2 PCR Test Positivity Among Healthcare System and Medical School Employees Calling the Occupational Health Call Center between December 28, 2020, and April 29, 2021

| COVID-19 Vaccine Dose[a] | SARS-CoV-2 Positive Among Those Vaccinated, No. (%) | SARS-CoV-2 Positive Among Those Unvaccinated, No. (%) | Vaccine Effectiveness, % (95% CI) |
|---|---|---|---|
| Dose 1 | 46 (6.0) | 590 (22.6) | 73.7 (65.0–80.2) |
| Dose 2 | 23 (2.7) | 590 (22.6) | 88.3 (82.4–92.2) |

Note. CI, confidence interval.
[a]Comparison group is calls to the COVID-19 Occupational Health Call Center among employees who had received zero doses of a COVID-19 vaccine as of the call date.

by positive versus negative SARS-CoV-2 test results. Among those testing positive for SARS-CoV-2, we compared demographics, employee details, SARS-CoV-2 exposure history, and symptoms by vaccination status using the $\chi^2$ and Fisher exact tests (cf, there was no clustering by employee). All analyses were performed in SAS version 9.4 software (SAS Institute, Cary, NC).

## Results

In total, 7,736 calls were placed to the COVID-19 call center between December 28, 2020, and April 29, 2021; 4,239 calls were included in the final study cohort after exclusions (Supplementary Material 1). Epidemiologic curves of employees testing positive for SARS-CoV-2 by vaccination status and COVID-19 cases in the St. Louis area are provided in Supplementary Material 2 and 3.

Overall, 82% of calls were from female employees, and the median age was 35 years (interquartile range, 28–46). Overall, the 659 employees who tested positive for SARS-CoV-2 were more likely to have had a non–work-related SARS-CoV-2 exposure (39.4% vs 21.1%; $P < .01$) and were more likely to live with a person with COVID-19 (31.1% vs 14.1%; $P < .01$) than the 3,580 employees who tested negative for SARS-CoV-2.

Among employees who called the call center with COVID-19 symptoms or an exposure, the proportion of unvaccinated

**Table 2.** Comparison by Vaccination Status Among Callers to the Employee Health Call Center Who Tested Positive for SARS-CoV-2 between December 28, 2020, and April 29, 2021

| Variable | COVID-19 Vaccination Status | | | *P* Value, 2 Doses Versus Unvaccinated | *P* Value, 1 Dose Versus Unvaccinated | *P* Value, 2 Dose Versus 1 Dose |
|---|---|---|---|---|---|---|
| | 2 Doses, No. (%) | 1 Dose, No. (%) | Unvaccinated, No. (%) | | | |
| Total No. | 23 | 46 | 590 | | | |
| **Employee demographics** | | | | | | |
| Age 18–35 y | 8 (34.8) | 15 (32.6) | 328 (55.6) | .14 | **<.01** | .29 |
| Age 36–49 y | 9 (39.1) | 11 (23.9) | 155 (26.3) | | | |
| Age ≥50 y | 6 (26.1) | 20 (43.5) | 107 (18.1) | | | |
| Male | 4 (17.4) | 8 (17.4) | 126 (21.4) | .65 | .53 | 1 |
| **Potential SARS-CoV-2 exposure** | | | | | | |
| Had a known, non–work-related SARS-CoV-2 exposure (n=653) | 14 (60.9) | 25 (54.3) | 218 (37.3) | **.02** | **.02** | .61 |
| Live with or ongoing contact with person with known or suspected COVID-19 (n=655) | 13 (56.5) | 24 (53.3) | 167 (28.4) | **<.001** | **<.01** | .80 |
| On-site work versus remote work (n=655) | 22 (95.7) | 42 (91.3) | 528 (90.1) | .38 | .79 | .51 |
| Healthcare provider job role (n=647) | 18 (78.3) | 30 (65.2) | 343 (59.3) | .07 | .43 | .27 |
| **COVID-19 symptoms[a]** | | | | | | |
| Cough | 11 (47.8) | 27 (58.7) | 298 (50.5) | .80 | .28 | .39 |
| Muscle aches | 6 (26.1) | 12 (26.1) | 203 (34.4) | .41 | .25 | 1 |
| Sore throat | 8 (34.8) | 12 (26.1) | 181 (30.7) | .68 | .51 | .45 |
| Fever | 2 (8.7) | 2 (4.3) | 143 (24.2) | .09 | **<.01** | .47 |
| Loss of smell | 5 (21.7) | 11 (23.9) | 118 (20.0) | .84 | .53 | .84 |
| Loss of taste | 5 (21.7) | 9 (19.6) | 97 (16.4) | .50 | .58 | .83 |
| Joint aches | 1 (4.3) | 7 (15.2) | 77 (13.1) | .22 | .68 | .18 |
| New diarrhea | 1 (4.3) | 2 (4.3) | 44 (7.5) | .57 | .43 | 1 |
| Trouble breathing | 1 (4.3) | 3 (6.5) | 31 (5.3) | .85 | .71 | .72 |
| Worse diarrhea | 0 (0.0) | 0 (0.0) | 2 (0.3) | .78 | .69 | |
| Other | 17 (73.9) | 33 (71.7) | 474 (80.3) | .45 | .16 | .85 |

Note. Bold indicates statistical significance.
[a]COVID-19 symptoms reported from discrete questions in the occupational-health call-center script. A large proportion of employees reported "other" symptoms as noted in a free-text section.

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employees who tested positive for SARS-CoV-2 was 22.6% compared to 6.0% among employees who had received 1 COVID-19 vaccine dose and 2.7% among employees who had received 2 COVID-19 vaccine doses (Table 1). Thus, the COVID-19 vaccine effectiveness rates were 73.7% (95% confidence interval [CI], 65.0%–80.2%) for 1 dose of vaccine and 88.3% (95% CI, 82.4%–92.2%) for 2 doses of a COVID-19 vaccine.

Among employees who tested positive for SARS-CoV-2, we detected some differences in demographics, exposure, and symptoms by COVID-19 vaccination status (Table 2). Employees who had received either 1 or 2 doses of COVID-19 vaccine who had a COVID-19 breakthrough infection were more likely to have had a non–work-related SARS-CoV-2 exposure and were more likely to live with a person with COVID-19 than unvaccinated employees who tested positive. Employees who tested positive for SARS-CoV-2 after receiving 1 vaccine dose were older than unvaccinated employees who tested positive. Employees who received 1 vaccine dose and contracted a breakthrough infection were less likely to report fever at the time of the call compared to unvaccinated employees who tested positive.

## Discussion

Using real-world operational data from employees of an academic medical center and affiliated healthcare system, we identified only a small number of COVID-19 vaccine breakthrough infections and we found high vaccine effectiveness against SARS-CoV-2 infection following 1 dose or 2 doses of COVID-19 vaccine. This finding supports other findings of a small proportion of COVID-19 cases being vaccine breakthrough infections in early 2021.[3] This finding also supports vaccine clinical trial data[4,5] and observational studies of vaccination effectiveness among healthcare workers during the same period as our study.[6,7] We also found that those with a breakthrough infection were more likely to have a non–work-related SARS-CoV-2 exposure and were more likely to be living with someone with COVID-19 than those testing positive who were unvaccinated. These findings suggest that exposure in household settings contributed to most breakthrough infections.

Our study had several limitations. Although we found high vaccine effectiveness in our study period when the original SARS-CoV-2 strain was circulating,[8] vaccine effectiveness has been shown to vary with subsequent SARS-CoV-2 variants[9] and to decline over time.[10] Our data source was call center data, which may have included inaccuracies or inconsistencies in responses. Vaccination status was self-reported and was not verified. The call center collected vaccination dates and whether the employee was vaccinated through work or another entity, but not vaccine manufacturer, so it is possible that some employees received a vaccine requiring only 1 dose. However, 95% of employees reported being vaccinated by his or her employer, and the healthcare system was only offering mRNA vaccines (ie, that required 2 doses) during the study period; thus, we examined 2-dose vaccine effectiveness. Our data provide additional important, HCP-focused evidence to guide future COVID-19 vaccination policies in healthcare settings.

The small number of COVID-19 vaccine breakthrough infections highlights the importance of vaccination to protect HCP and prevent the spread of SARS-CoV-2 in healthcare settings. These data can be utilized to guide COVID-19 vaccination policies in healthcare settings.

**Supplementary material.** To view supplementary material for this article, please visit https://doi.org/10.1017/ash.2022.299.

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

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