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Publication Date

2024-02-05

DOI

10.1002/ajim.23570

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Received: 8 June 2023 | Revised: 24 January 2024 | Accepted: 24 January 2024

DOI: 10.1002/ajim.23570

RESEARCH ARTICLE

AMERICAN JOURNAL OF INDUSTRIAL MEDICINE WILEY

Risk of subsequent SARS-CoV-2 infection among vaccinated employees with or without hybrid immunity acquired early in the Omicron-predominant era of the COVID-19 pandemic

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Abstract

Background: Hybrid immunity, from COVID-19 vaccination followed by SARS-CoV-2 infection acquired after its Omicron variant began predominating, has provided greater protection than vaccination alone against subsequent infection over 1–3 months of observation. Its longer-term protection is unknown.

Methods: We conducted a retrospective cohort study of COVID-19 case incidence among healthcare personnel (HCP) mandated to be vaccinated and report on COVID-19-associated symptoms, high-risk exposures, or known-positive test results to an employee health hotline. We compared cases with hybrid immunity, defined as incident COVID-19 during the first 6 weeks of Omicron-variant predominance (run-in period), to those with immunity from vaccination alone during the run-in period. Time until COVID-19 infection over 13 subsequent months (observation period) was analyzed by standard survival analysis.

Results: Of 5867 employees, 641 (10.9%, 95% confidence interval [CI]: 10.1%–11.8%) acquired hybrid immunity during the run-in period. Of these, 104 (16.2%, 95% CI: 13.5%–19.3%) experienced new SARS-CoV-2 infection during the 13-month observation period, compared to 2177 (41.7%, 95% CI: 40.3%–43.0%) of the 5226 HCP without hybrid immunity. Time until incident infection was shorter among the latter (hazard ratio: 3.09, 95% CI: 2.54–3.78).

Conclusions: In a cohort of vaccinated employees, Omicron-era acquired SARS-CoV-2 hybrid immunity was associated with significantly lower risk of subsequent infection over more than a year of observation—a time period far longer than previously reported and during which three, progressively more resistant, Omicron subvariants became predominant. These findings can inform institutional policy and planning for future COVID-19 additional vaccine dosing requirements for employees, for surveillance programs, and for risk modification efforts.

KEYWORDS

COVID-19, hybrid immunity, SARS-CoV-2, vaccination

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1 | INTRODUCTION

The SARS-CoV-2 Omicron variant and its subvariant descendants have predominated among circulating strains causing COVID-19 in the United States since December 2021. By June 2022, this variant was estimated to have infected 46% of the global population,[1] and approximately 36% of the workforce at Zuckerberg San Francisco General Hospital (ZSFG) had reported an Omicron-era positive test result to the medical center's Employee Health Service (EHS). Recent reports indicate people who received COVID-19 vaccination and then acquired SARS-CoV-2 during the first few months after Omicron first predominated (i.e., those with Omicron-era acquired hybrid immunity from both vaccination and Omicron variant infection) have greater protection against subsequent re-infection over observation periods of up to 3 months than those who received vaccination alone.[2–4] The durability of protection from such hybrid immunity, however, has not been established. Employees who are healthcare personnel (HCP) working in institutions such as ZSFG that mandate vaccination to work on site and require employees to report any COVID-19-associated symptoms, high-risk exposures, or known positive test results to the institution's occupational health program comprise an ideal group in which to examine the long-term risk of infection associated with COVID-19 hybrid immunity versus that of immunity due to vaccination alone.

As a quality improvement (QI) endeavor to inform our institution's COVID-19 policies, we explored the risk of subsequent infection associated with COVID-19 hybrid immunity by conducting a retrospective cohort study of our HCP, all of whom were required to have completed at least a primary COVID-19 vaccination series more than a month before the first Omicron subvariants, BA.1 and BA.2, began to predominate. Because a large subset of these HCP had documented COVID-19 infection within the first 6 weeks after the Omicron variant of SARS-CoV-2 began to predominate among circulating viral isolates, we examined their risk of subsequent infection over a 13-month observation period and compared it to that of all other HCP.

2 | METHODS

Using a retrospective occupational cohort study design with a run-in period, as has been done previously by groups conducting observational studies of other diseases,[5,6] we analyzed positive SARS-CoV-2 test results reported to the medical center EHS COVID-19 hotline of ZSFG—a public health medical center located in San Francisco, CA. The ZSFG campus is under the purview of the city's Department of Public Health and serves as the only Level I trauma center for the 1.5 million residents of San Francisco and northern San Mateo County. It houses the largest acute inpatient and rehabilitation hospitals for psychiatric patients in the city. The buildings on the ZSFGs campus house 425 general and psychiatric acute care beds and 89 skilled nursing care beds, research laboratories, multiple outpatient clinics, and administrative support resources.

The EHS COVID-19 hotline was established in April 2020 to facilitate management of HCP with potential SARS-CoV-2 infection, including testing, isolation, and return to work. Self-reporting by HCP to the hotline of any symptoms consistent with COVID-19, high-risk exposure to someone with SARS-CoV-2 infection, or a positive COVID-19 test result is mandated for all individuals who are working in any inpatient, outpatient, research, administrative, or other nonclinical area at the ZSFG campus. This includes both employees of the medical center and its affiliated academic institution whose primary assignment is at this medical center. Based on Human Resources and EHS data, we estimated the total employed population of HCP working regularly at the center to be 5867 as of February 2023, of whom approximately 60% were San Francisco Department of Public Health (SFDPH) employees and 40% University of California San Francisco (UCSF) employees. We excluded from this analysis any SFDPH or UCSF employees, students, or trainees who reported positive test results but did not work regularly at the ZSFG campus.

Data for all positive HCP SARS-CoV-2 tests reported to EHS are entered into a secure database containing the medical record number, name, job classification and work location, and the date and type of positive test result. Confirmatory COVID-19 test results include both rapid antigen and nucleic acid amplification test (NAAT) results. The former could be a rapid antigen performed by trained staff at the medical center EHS testing site or by the employee at home; the latter a rapid NAAT performed at the EHS testing site. Confirmatory COVID-19 tests also include nucleic acid amplification assays, such as polymerase chain reaction or transcription mediated amplification, either performed in the medical center's clinical microbiology laboratory, results of which are transmitted directly to hotline staff, or at outside laboratories that meet Clinical Laboratory Improvement Amendments (CLIA) certification standards. In the latter case, HCP are asked to send a digital copy of the test result to hotline staff. Any HCP reporting a positive rapid antigen self-test result was encouraged to obtain a confirmatory amplification test at a CLIA-certified laboratory. For analytic purposes, we defined the incident date as that of the initial positive test.

Compliance of SFDPH employees at the ZSFG campus with the COVID-19 vaccination mandate to receive a United States Food and Drug Administration (FDA)-approved primary vaccination series by September 30, 2021, and at least one booster additional vaccine dose by February 28, 2022, was monitored by SFDPH Human Resources. At least 98% of HCP were compliant with the primary vaccination mandate by October 31, 2021 (more than 6 weeks before Omicron became the predominant circulating SARS-CoV-2 variant in the United States), and at least 96% were compliant with subsequent institutional mandate to receive an additional vaccination dose by January 31, 2022. Some noncompliance may have reflected Human Resources granting an exemption from the required vaccination. However, the number of such exemptions granted by ZSFG Human Resources was unavailable to us. While exemptions generally increase noncompliance with vaccination, some apparently noncompliant individuals might have chosen for convenience to be vaccinated elsewhere and not provided the documentation to Human

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Resources. Vaccination compliance data for UCSF employees who work regularly at the ZSFG campus was not available to us.

We categorized all HCP with an incident COVID-19-hotline-confirmed positive test result occurring between December 18, 2021, and January 31, 2022 (the run-in period), as cases having early Omicron-era-acquired hybrid immunity (i.e., due to both vaccination and an infection acquired during the first 6 weeks that the Omicron variant predominated among circulating SARS-CoV-2 strains). All other HCP (i.e., those without an incident COVID-19-hotline-confirmed positive test result occurring between December 18, 2021, and January 31, 2022) were assumed to lack early Omicron-era-acquired hybrid immunity and were defined as having vaccination-only conferred immunity. We analyzed the incidence of hotline-confirmed COVID-19 test results over the subsequent 13 months from February 1, 2022, through February 28, 2023 (the observation period) among both groups.

The primary outcome analyzed was time until a first distinct episode of infection occurred during the observation period. This was a pragmatic, effectiveness outcome because it informed decision-making as to whether an employee should be isolated from work. A distinct episode was defined as a true new episode of SARS-CoV-2 infection documented by a positive test result for which no previous positive result was reported within the last 30 days (residual PCR positivity had been reported early in the pandemic by many groups to typically last for up to a month in immunocompetent individuals[7]). Moreover, if a positive test result occurred more than 30 but less than 90 days after a prior positive result, hotline staff would order both antigen and nucleic acid amplification testing and confirm with the employee whether new onset of acute COVID-19-compatible symptoms or a high-risk exposure had occurred to determine if this represented a true new infection as opposed to the presence of residual SARS-CoV-2 nucleic acid from an earlier confirmed infection.

We calculated descriptive statistics for days elapsed until infection and the frequencies of outcomes and their associated 95% confidence intervals (CIs). We used Fisher's exact test to assess differences between frequencies of reinfection during the observation period by hybrid immune status and Chi-square analysis to assess differences in demographic characteristics by hybrid immunity status. We employed a standard survival analysis approach to test for differences between groups (early hybrid immunity vs. vaccination-only conferred immunity) in the time to first, distinct infection during the observation period. For this analysis, hybrid-immune individuals were left-censored for 30 days following their hybrid-defining infection, which is until a date ranging from January 18 to March 1, 2022. Survival time was calculated as the number of days between the beginning of the study period, or the left-censor date for left-censored individuals, and the positive test result date or the end of the study period. We estimated the hazard ratio and its 95% CI for vaccination-only relative to hybrid immunity using R statistical software (The R Project for Statistical Computing, version 4.2.3).

The work described herein was conducted as an EHS quality improvement project. A summary of the methods and results of this project, which were the basis for this paper and contain no personal identifiers, was submitted to the medical center's institutional review board, which determined that it was exempted from review of research involving human subjects.

3 | RESULTS

During the first 6 weeks of Omicron variant predominance in California (December 18, 2021, through January 31, 2022, the study run-in period, there were 641 incident HCP COVID-19 cases, accounting for 10.9% (95% CI: 10.1%–11.8%) of the estimated workforce of 5867. None of these 641 cases had a subsequent positive test result reported to the ZSFG EHS within 30 days after the initial Omicron infection that represented residual PCR positivity. During the 13-month observation period, 104 of these 641 (16.2% (95% CI: 13.5%–19.3%) had a distinct new SARS-CoV-2 infection reported. Of the 104, a single case (<1%) occurred before Day 90, specifically on Day 80 following a high-risk exposure associated with symptoms and a positive rapid antigen test. Two of these 104 cases also experienced a second reinfection (1.9%; 95% CI: 0.23%–6.78%) during the observation period.

During this same observation period, 2177 (41.7%, 95% CI: 40.3%–43.0%) of the remaining 5226 HCP, who had not acquired hybrid immunity during the run-in period, had a distinct new SARS-CoV-2 infection. Among these 2177, there were 76 (3.5%; 95% CI: 2.8%–4.5%) who experienced a second infection during the observation period. The difference between the proportion of those with a second infection among those with early infection (1.9%) and those with a second infection in the group that was initially Omicron naïve (3.5%) was not statistically significant ($p > 0.5$). By the end of the observation period, a total 2818 (48.0%, 95% CI: 46.8%–49.3%) of the entire 5867 HCP workforce, including those infected during the first 6 weeks of the Omicron-predominant era, had acquired Omicron-era hybrid immunity.

A comparison of the available demographic data of these two study groups is provided in Table 1. There were no statistically significant differences in the age, sex, or occupational category between those with hybrid immunity versus those with vaccination-only conferred immunity. While differences in the proportions of race and ethnicity between groups were statistically significant, the magnitudes of these differences were minor.

Among the 104 HCP with early, Omicron-era-acquired hybrid immunity who had incident infection during the 13-month observation period, median time to a distinct new infection was 266 days. For the 2177 HCP who began this observation period without such early hybrid immunity, the median time was 155 days. As shown in Figure 1, time until the incident infection was significantly shorter for those without hybrid immunity (hazard ratio: 3.09, 95% CI: 2.54–3.78). The protective effectiveness of early, Omicron-era-acquired hybrid immunity appeared greatest during the first 9 months of the observation period. At 6 months into the observation period, only 5.1% (95% CI: 3.6%–7.2%) of those who began with hybrid immunity had a new distinct infection compared to 26.1%

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TABLE 1 Characteristics of 2818 healthcare personnel reporting a positive COVID-19 test result between December 18, 2021, and February 28, 2023.

	Hybrid immunity	Vaccine-only conferred immunity	*p*-Value
Age,[a] mean (SD)	42.9 (11.1)	43.3 (10.8)	NS
Sex,[a] *N* (%)			NS
Male	206 (32.4)	645 (29.7)	
Female	430 (67.6)	1528 (70.3)	
Race,[a] *N* (%)			<0.001
AANHPI	241 (39.3)	918 (44.3)	
Black	80 (13.0)	152 (7.3)	
White	143 (23.3)	537 (25.9)	
Other	150 (24.4)	465 (22.4)	
Ethnicity[a] (Hispanic, Latino/a/x, or Spanish origin), *N* (%)			0.002
Yes	122 (19.9)	305 (14.7)	
No	491 (80.1)	1773 (85.3)	
Occupation,[a] *N* (%)			NS
Patient-facing	464 (81.7)	1564 (81.6)	
Other	104 (18.3)	352 (18.4)	

Abbreviation: AANHPI: Asian American, Native Hawaiian, Pacific Islander.
[a]Excluded due to missing data: age (*N* = 6), sex (*N* = 12), race (*N* = 6), ethnicity (*N* = 6), and occupation (*N* = 334).

(95% CI: 24.2%–27.3%) of those without. At 9 months the comparable proportions were 8.3% (95% CI: 6.3%–10.7%) and 32.5% (95% CI: 31.2%–33.7%) for the two groups.

4 | DISCUSSION

Hybrid immunity, from COVID-19 vaccination followed by SARS-CoV-2 infection acquired after its Omicron variant began predominating, has been reported to provide greater protection than vaccination alone against subsequent infection over observation periods of up to 3 months.[2–4] Our findings indicate that, during more than 1 year of observation, the risk of Omicron variant SARS-CoV2 infection among those with hybrid immunity continued to be significantly less (by three-fold over the entire observation period) than among those with immunity conferred by previous vaccination alone. In addition, this significantly reduced risk persisted despite three progressively more resistant subvariants successively emerging to predominance during the observation period (BA.4 and BA.5 on June 18, 2022, BQ on November 27, 2022, and XBB, on January 29, 2023.[8])

A general population study in South Korea reported incident infection over 1 month (August 2022) and, as in our study, included persons with prior Omicron era infection (acquired 1–7 months beforehand), who had previously received two to four doses of an mRNA vaccine.[4] This group was compared to persons with the same vaccination history but without hybrid immunity. The observed effectiveness of hybrid immunity was 89.5% (95% CI: 89.2%–89.8%) and 94.3% (95% CI: 94.1%–94.4%) for prior BA.1 or BA.2 infections, respectively, compared to 16.1% (95% CI: 15.5%–16.6%) among those with vaccination alone. A Canadian group reported results of a vaccinated HCP cohort they observed between March 27, 2022, and June 4, 2022, when BA.2 (one of the two initial Omicron subvariants to appear) was the predominant circulating variant.[3] The subset of these HCP with hybrid immunity, who had been vaccinated and acquired BA.1 infection, had a higher degree of short-term protection than those with a primary series of vaccination alone and no Omicron era infection. The most recently published study addressing this issue we are aware of is a nationwide study of persons who sought medical attention for symptomatic SARS-CoV-2 infection in Singapore, in which the observation period included symptomatic BA.4 and BA.5 reinfections occurring from October 1, 2022, to November 1, 2022, and XBB reinfections from October 18, 2022, to November 1, 2022.[2] This study reported increased protection conferred by previous BA.2 infection, although it appeared to wane in the context of XBB reinfection. However, rapid antigen tests are available for purchase outside of healthcare facilities in Singapore, and illness caused by the Omicron variant and its descendent subvariants has been reported to be less severe than with previously predominating variants.[9] Thus, if many individuals with mild or moderate symptoms self-tested positive at home and were not reported, the generalizability of these results would be limited. Although the pace of reinfection among those with hybrid immunity in our study did increase over time, the incremental change never exceeded that of the vaccination-only group, even during the final 4 months of our observation period when the most resistant Omicron sub-variant described to date, XBB, was emerging to predominance. Thus, our findings suggest the effectiveness of hybrid immunity was not completely attenuated, even after 13 months and evolution of the initial predominant Omicron subvariant virus to new predominating subvariants with progressively more resistance to neutralizing antibodies.

Our results could have relevance for designing future studies and policies to address the difficulty of inducing robust, persistent immunity via additional COVID-19 vaccine dosing when negative immune imprinting has occurred.[10–14] This immunologic phenomenon, well-described in influenza vaccine studies,[15,16] can lead to decreased vaccine effectiveness when the antigens in a recently received vaccine formulation are more similar to those of a previously received vaccine than to the antigens in the currently circulating viral strain. Such negative imprinting has been reported in the Omicron era when the predominant Omicron subvariant that served as the model for antigens in the bivalent COVID-19 formulation approved by the FDA in August 2022, was superseded in predominance just a few

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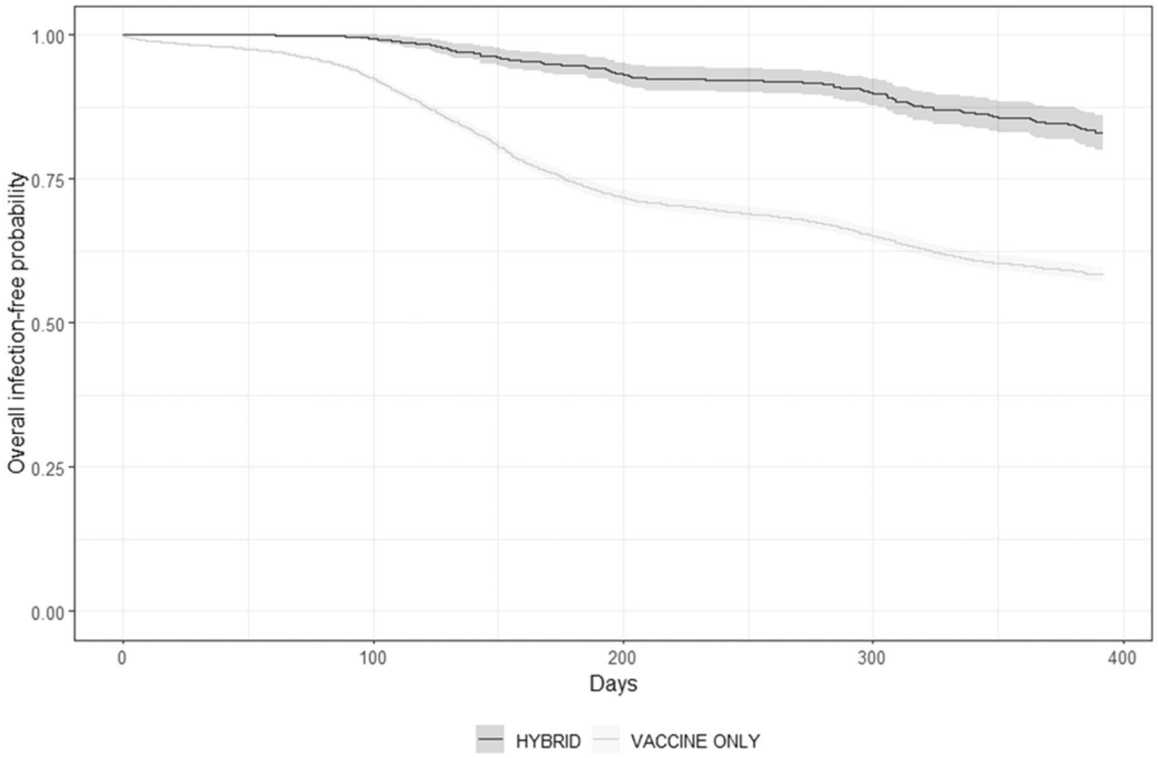

FIGURE 1 Kaplan–Meier plot comparing COVID-19 hybrid immunity with vaccination-only immunity on the overall infection-free probability during 13 months of observation from February 1, 2022, through February 28, 2023. Hybrid immunity cases were left-censored for the first 30 days following initial infection date, which occurred between December 18, 2021 and January 31, 2022. Time until incident infection was shorter for the vaccine immunity alone compared to hybrid immunity (hazard ratio: 3.09, 95% confidence interval: 2.54–3.78).

months later by a more resistant subvariant.[13,14] Recent evidence suggests that optimal vaccination strategies for mitigating such negative imprinting going forward may differ depending on the degree of hybrid immunity present.[17]

There are potential limitations of our study. While our analysis assumes 100% of the workforce was vaccinated, we can only verify that 98% of the SFDPH employees working regularly at the ZSFG medical center received a primary vaccination series six or more weeks before the Omicron variant became the predominant circulating SARS-CoV-2 variant in the United States. While some of these unverified individuals may have been granted an exemption from vaccination by human resources (data not available to us to protect employee privacy), others may have been vaccinated elsewhere but did not provide the documentation to human resources. Given the large effect size we observed for hybrid immunity compared to that conferred by vaccination alone, it would not likely have been substantively impacted by incorrectly categorizing such a small proportion of the cohort. We were unable to access vaccination data about the UCSF employees working regularly at the ZSFG medical center but have no reason to suspect that their compliance was any less than that of SFDPH employees. In addition, case finding for both those with and without hybrid immunity was likely to be complete because HCP were required to self-report to the hotline having a positive COVID-19 test result or experiencing any symptoms consistent with COVID-19 or a high-risk exposure to someone with SARS-CoV-2 infection. Reporting any of these would have led employee health hotline staff to require an employee to test negative to continue working on site.

We acknowledge that our choice of 30-day censorship of observation for hybrid immunity was empiric. The single case of illness in the 60- to 90-day window and no reports to ZSFG EHS of residual PCR positivity during this window among those with early Omicron-era-acquired hybrid immunity supports this 30-day cut-off. We did not have demographic data for 3049 employees with vaccination-only conferred immunity group who did not report COVID-19 infection during the observation period, thus limiting our ability to analyze demographic confounders. However, among those with infection, the only statistically significant proportional differences were in race and ethnicity; and these differences were small and unlikely to account for the magnitude of the hybrid immunity protective effect that we observed.

Another limitation is that we do not have laboratory markers of protective immune responses, such as neutralizing antibodies, obtained at the time that our observation period began. Also, our hotline was a passive surveillance system. Hence, even though mandated, HCP who did not adhere to reporting requirements would not have appeared in our data set. We are not aware, however, of a subset of our HCP COVID-19 cases who did not report a known positive test result (although reporting could be delayed if an employee was on vacation or had already initiated isolation). In addition, there was an incentive for HCP to report positive test

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results as documentation for obtaining special COVID-19 sick leave. Conversely, HCP would understand that nondisclosure of a known positive test result could have serious adverse career and potentially even liability consequences. We have no reason to believe a tendency to under-report would have differed between groups with hybrid versus vaccine-conferred only immunity.

Because our database did not consistently obtain data before the Omicron-predominant era of the COVID-19 pandemic, we were unable to assess how infection before Omicron predominance might have impacted case incidence over the study observation period. However, there is a meta-analysis of cohort, cross-sectional, and case–control studies that examined the protective effectiveness of hybrid immunity against the Omicron infection when the prior infection that established hybrid immunity was acquired before Omicron began to predominate. Several of the studies examined in that meta-analysis involved comparisons of such hybrid immunity to immunity conferred solely by vaccination, as in our analysis, and reported that hybrid immunity effectiveness ranged from 30% to 60% higher than vaccination alone.[18] Thus, if pre-Omicron infection had a confounding effect in our study, it most likely would have been a protective one and more prevalent among those who escaped infection during the first 6 weeks of the Omicron era.

Lastly, the generalizability of our findings is limited to adults healthy enough to work at a medical center and may not apply to subpopulations unable to mount a normal immune response to SARS-CoV-2 vaccination or infection. For example, there has been a recent report that Omicron infection was associated with an increased rather than decreased risk of subsequent Omicron reinfection in residents of long-term care and retirement homes, likely due to less robust humoral hybrid immune responses in these elderly adults to natural infection and vaccination than to vaccination alone.[19] At present (November 2023), evolution of the predominant circulating SARS-C0V-2 strains that has occurred since our observation period ended on February 28, 2023, has not resulted in a large enough shift in SARS-CoV-2 surface antigen composition to cause another surge comparable to those observed in the early phase of omicron predominance. Thus, our findings likely remain generalizable. This might not continue to be the case should a new Omicron subvariant or an entirely new SARS-CoV-2 variant appear that has enough antigen shift and resistance to the neutralizing antibodies induced by earlier Omicron infections that a new surge in viral infections would result.

Despite these limitations, our findings suggest a durable protective effect of Omicron era acquired hybrid immunity, which nearly half our workforce had acquired by the end of the observation period in February 2023. These findings may be informative to leaders of healthcare facilities and other institutions concerned about COVID-19 transmission among their employees as they plan future additional vaccine dosing requirements and campaigns, surveillance programs, and risk modification for COVID-19.

AUTHOR CONTRIBUTIONS

Dr. Mark A. Jacobson conceived of this project and was involved in the design, acquisition of the data, analysis of the data, drafting the work, and interpretation of the results. He reviewed the manuscript for important intellectual content, gave final approval of the version to be published, and agrees to be accountable for all aspects of the work in ensuring that questions related to the accuracy or integrity of any part of the work are appropriately investigated and resolved. Dr. Paul D. Blanc was involved in the design, acquisition of the data, analysis of the data, drafting the work, and interpretation of the results. He reviewed the manuscript for important intellectual content, gave final approval of the version to be published, and agrees to be accountable for all aspects of the work in ensuring that questions related to the accuracy or integrity of any part of the work are appropriately investigated and resolved. Dr. Jacqueline Tulsky was involved in the acquisition of the data, drafting the work, and interpretation of the results. She reviewed the manuscript for important intellectual content, gave final approval of the version to be published, and agrees to be accountable for all aspects of the work in ensuring that questions related to the accuracy or integrity of any part of the work are appropriately investigated and resolved. Dr. Monica Tilly was involved in the acquisition of the data and interpretation of the results. She reviewed the manuscript for important intellectual content, gave final approval of the version to be published, and agrees to be accountable for all aspects of the work in ensuring that questions related to the accuracy or integrity of any part of the work are appropriately investigated and resolved. Dr. Raymond Meister was involved in the acquisition of the data and interpretation of the results. He reviewed the manuscript for important intellectual content, gave final approval of the version to be published, and agrees to be accountable for all aspects of the work in ensuring that questions related to the accuracy or integrity of any part of the work are appropriately investigated and resolved. Dr. Will Huen was involved in the acquisition of the data and interpretation of the results. He reviewed the manuscript for important intellectual content, gave final approval of the version to be published, and agrees to be accountable for all aspects of the work in ensuring that questions related to the accuracy or integrity of any part of the work are appropriately investigated and resolved. Dr. James E. McNicholas was involved in the, design, acquisition of the data, analysis of the data, drafting the work, and interpretation of the results. He reviewed the manuscript for important intellectual content, gave final approval of the version to be published, and agrees to be accountable for all aspects of the work in ensuring that questions related to the accuracy or integrity of any part of the work are appropriately investigated and resolved.

ACKNOWLEDGMENTS

We are grateful to the entire COVID-19 hotline staff of the Zuckerberg San Francisco General Hospital Employee Health Service (ZSFG EHS) without whose diligent and thorough effort in managing newly infected employees this report would not have been possible.

CONFLICT OF INTEREST STATEMENT

The authors declare that there are no conflicts of interest.

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John Meyer declares that he has no conflict of interest in the review and publication decision regarding this article.

DATA AVAILABILITY STATEMENT

The data are not publicly available due to privacy or ethical restrictions.

ETHICS APPROVAL AND INFORMED CONSENT

The work described herein was conducted as a quality improvement project of the ZSFG EHS. The summary of the methods and results of this project, which are the basis for this paper and contain no personal identifiers, was submitted to the Institutional Review Board of the University of California San Francisco, which determined that it was exempted, as a summary of results of a quality improvement project lacking personal identifiers, from review of research involving human subjects.

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How to cite this article: Jacobson MA, Blanc PD, Tulsky J, et al. Risk of subsequent SARS-CoV-2 infection among vaccinated employees with or without hybrid immunity acquired early in the Omicron-predominant era of the COVID-19 pandemic. *Am J Ind Med*. 2024;1-7. doi:10.1002/ajim.23570

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