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# Contact-Tracing Outcomes Among Household Contacts of Fully Vaccinated Coronavirus Disease 2019 (COVID-19) Patients: San Francisco, California, 29 January–2 July 2021

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**Background.** The extent to which vaccinated persons diagnosed with coronavirus disease 2019 (COVID-19) can transmit to other vaccinated and unvaccinated persons is unclear.

**Methods.** Using data from the San Francisco Department of Public Health, this report describes outcomes of household contact tracing during 29 January–2 July 2021, where fully vaccinated patients with COVID-19 were the index case in the household.

**Results.** Among 248 fully vaccinated patients with breakthrough infections, 203 (82%) were symptomatic and 105 were identified as the index patient within their household. Among 179 named household contacts, 71 (40%) contacts tested, over half (56%) were fully vaccinated and the secondary attack rate was 28%. Overall transmission from a symptomatic fully vaccinated patient with breakthrough infection to household contacts was suspected in 14 of 105 (13%) of households. Viral genomic sequencing of samples from 44% of fully vaccinated patients showed that 82% of those sequenced were infected by a variant of concern or interest and 77% by a variant carrying mutation(s) associated with resistance to neutralizing antibodies.

**Conclusions.** Transmission from fully vaccinated symptomatic index patients to vaccinated and unvaccinated household contacts can occur. Indoor face masking and timely testing of all household contacts should be considered when a household member receives a positive test result in order to identify and interrupt transmission chains.

**Keywords.** COVID-19; contact tracing; household transmission; breakthrough; vaccination.

Real-world data demonstrate that vaccines are effective at preventing asymptomatic and symptomatic severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) infection, the virus that causes coronavirus disease 2019 (COVID-19); however, breakthrough infections can occur [1, 2]. While early studies suggested that vaccinated persons with breakthrough infections have a lower viral load and were less likely to transmit disease to household contacts compared with infected unvaccinated persons, data collected in the era of the Delta variant (B.1.617.2) suggest no difference in viral loads for vaccinated and unvaccinated persons diagnosed with SARS-CoV-2 [3–7]. More data are needed to assess whether fully vaccinated persons who become infected can transmit

SARS-CoV-2 to others, particularly in high-risk household settings where people are generally unmasked and transmission is common.

By 2 July 2021, nearly 75% of San Franciscans aged 12 years and older were fully vaccinated with an authorized COVID-19 vaccine (60% Pfizer, 32% Moderna, and 8% Johnson & Johnson) and over half of household contacts identified through contact tracing were fully vaccinated. In order to better understand COVID-19 transmission from fully vaccinated persons to their contacts, the San Francisco Department of Public Health (SFDPH) used contact-tracing data to analyze attack rates among household contacts of fully vaccinated patients with breakthrough infections. This study includes data collected several months prior to and immediately after the Delta variant became predominant in California.

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## METHODS

### Identification of Fully Vaccinated COVID-19 Patients

During January 29–July 2, 2021, patients with laboratory-confirmed COVID-19 (positive reverse transcription–polymerase chain reaction [RT-PCR], loop-mediated amplification [LAMP], or detected antigen) reported within 10 days of specimen collection to SFDPH were assigned for case investigation

and contact tracing [8]. Persons reported as COVID-19 patients were interviewed to collect demographic, clinical, exposure, and vaccination data and to ask about close contacts during their infectious period (2 days before either symptom onset [or specimen collection date if the patient was asymptomatic] until the patient was isolated). COVID-19 symptoms were reviewed during the interview; asymptomatic patients denied any symptoms in the 2 weeks prior to testing. Mask-wearing was not assessed. Vaccination status was self-reported; missing or unknown vaccination dates were obtained from the California Immunization Registry. Fully vaccinated patients with breakthrough infections (COVID-19 patients) were those who received a positive SARS-CoV-2 test result 2 or more weeks after receiving the single-dose Johnson & Johnson vaccine or the second of either of the 2-dose series mRNA vaccines.

#### Household Contact Tracing and Epidemiologic Investigation

Vaccinated index patients were persons who lived with at least 1 other person and who were the first household member to receive a positive test result for SARS-CoV-2 or to experience COVID-19 symptoms. Household contacts were persons living in the same residence as the index patient during their infectious period. Secondary cases were infected household contacts suspected to have acquired infection following exposure to the fully vaccinated index patient during the infectious period. Co-primary index patients (2 household members who received positive test results or developed symptoms within 1 day of each other and were suspected to have acquired infection from a shared exposure outside the household) were not counted as secondary cases. Vaccinated persons who developed symptoms less than 2 weeks after receipt of their most recent vaccine dose were considered not fully vaccinated for this analysis and asymptomatic fully vaccinated persons with laboratory-confirmed COVID-19 in the 180 days before specimen collection were excluded. Fully vaccinated contacts were persons with an exposure 2 or more weeks after receiving the final dose of either a 1- or 2-dose vaccination series. Partially vaccinated contacts were persons who received at least 1 dose of vaccine but were not fully vaccinated. The median number of days between last vaccine dose and the test date was calculated. When a breakthrough case was identified, public health investigators contacted laboratories where specimens were originally analyzed and requested that specimens be sent for whole-genome sequencing. Sequencing results were reported to the health department as part of mandatory public health reporting requirements. Cycle threshold values were not reportable and not collected by the health department.

#### Analysis of Outcomes and Attack Rates

Based on the Centers for Disease Control and Prevention (CDC) recommendations at the time, unvaccinated (irrespective of symptoms) and symptomatic vaccinated household contacts

were referred for SARS-CoV-2 testing; as well, some asymptomatic fully vaccinated contacts opted to be tested [9]. Pearson chi-square tests were performed to assess the independence of testing and vaccination status among household contacts and the independence of testing and symptom status among fully vaccinated household contacts. Contact and testing databases were matched to ascertain testing results. The proportions of tested contacts who received a positive SARS-CoV-2 test result (secondary attack rate) and households with any secondary infections were calculated. Assuming a reasonably representative contact testing rate by symptom status, a secondary attack rate conditioned on contact symptom status (symptomatic, asymptomatic, unknown symptom status) was also calculated among all fully vaccinated contacts to address the higher likelihood of testing symptomatic household contacts. The positivity rate among those tested was applied to the total number of fully vaccinated contacts per symptom status group (eg, 11 symptomatic contacts multiplied by 0.44 positivity among tested = 4.8 new secondary cases) to quantify the number of cases that may have been identified if all contacts had been tested; these products were summed and divided by the total number of fully vaccinated contacts ( $n = 101$ ).

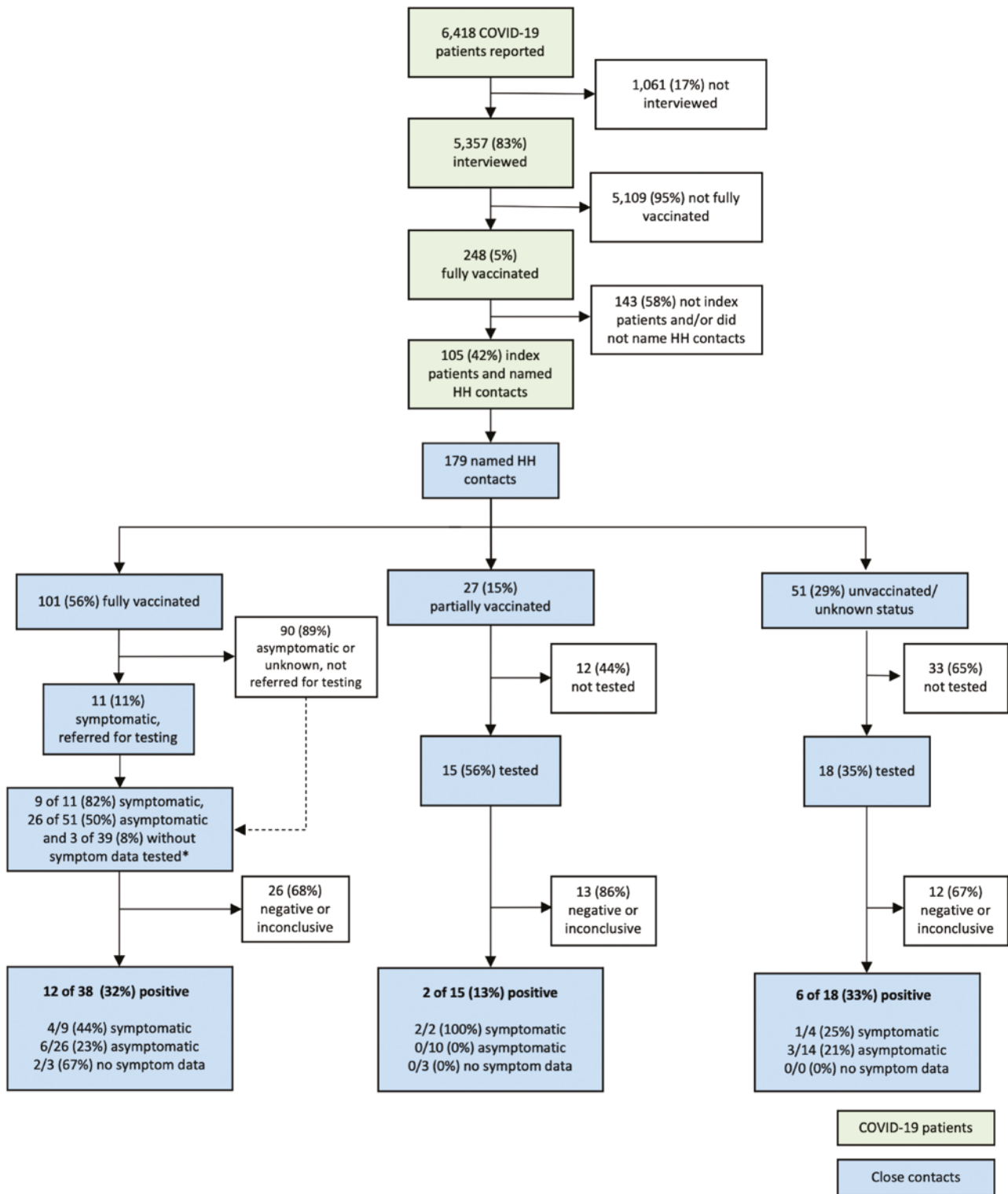
COVID-19 patient and contact characteristics and attack rates were stratified by demographic and clinical covariates, as well as variant exposure type. In households where positive contacts were identified, public health investigators assessed epidemiologic linkages to determine the likelihood of household transmission from the index case [10, 11]. This work was conducted as part of SFDPH COVID-19 surveillance; institutional review board approval and informed consent were not required.

## RESULTS

#### Characteristics of Fully Vaccinated Patients With COVID-19

Among 6418 persons with reported COVID-19 during 29 January–2 July 2021, 5357 (83.4%) were interviewed, among whom 248 (4.6%) fully vaccinated patients were identified (Figure 1), including 237 (96%) by RT-PCR or LAMP testing and 11 (4%) through antigen testing. Of note, 123 (50%) breakthrough cases were identified in the final 3 weeks of the study period at a time when fully vaccinated patients made up 44% (123/279) of all interviewed cases.

Among 248 fully vaccinated patients, 150 (60%) had received Pfizer, 59 (24%) Johnson & Johnson, and 39 (16%) Moderna vaccines (Table 1), and the median interval from receipt of the most recent dose of each vaccine to diagnosis was 64 days (interquartile range [IQR] = 44–86 days), 64 days (IQR = 40–78 days), and 65 days (IQR = 43–93 days), respectively. Over half of fully vaccinated patients with COVID-19 were men (126; 51%) and aged 18–39 years (152; 61%) (Table 1). The largest proportion of patients were among White (102; 41%), Asian



**Figure 1.** Flowchart showing contact tracing among household contacts of vaccinated COVID-19 patients with breakthrough infections in San Francisco, California, during 29 January–2 July 2021. \*Twenty-six asymptomatic fully vaccinated contacts and 3 additional individuals whose symptom statuses were unknown still opted to test and are included in the total fully vaccinated tested. Abbreviations: COVID-19, coronavirus disease 2019; HH, household.

(58; 23%), and Hispanic (57; 23%) persons. One-quarter (64) of fully vaccinated patients with COVID-19 reported at least 1 underlying medical condition. Two hundred and three (82%)

fully vaccinated patients with breakthrough infection were symptomatic. Among symptomatic patients, the most commonly reported symptoms were rhinorrhea (128; 63%), cough

**Table 1. Demographic and Clinical Characteristics of Fully Vaccinated Persons With Positive SARS-CoV-2 Test Results (n = 248), Household Index Patients (n = 105), Household Contacts (n = 179), and Secondary Attack Rates: San Francisco, California, 29 January–2 July 2021**

Characteristics	No. (%)			
	All Fully Vaccinated Persons With Positive SARS-CoV-2 Test Result	Fully Vaccinated Index Patients Who Named Household Contacts <sup>a</sup>	Household Contacts	Secondary Attack Rate, <sup>b</sup> No. of Household Contacts With Positive Test/No. of Household Contacts Tested (%)
Total	248 (100)	105 (100)	179 (100)	20/71 (28)
Median age, y (IQR)	35.0 (27-46)	35 (27-45)	31 (23-43)	N/A
<b>Age group<sup>c</sup></b>				
0-17 y	N/A	N/A	27 (15.1)	3/11 (27.3)
18-39 y	152 (61.3)	69 (65.7)	88 (49.2)	12/45 (26.7)
40-59 y	61 (24.6)	25 (23.8)	31 (17.3)	5/11 (45.5)
≥60 y	35 (14.1)	11 (10.5)	19 (10.6)	0/4 (0)
Unknown	0 (0)	0 (0)	14 (7.8)	0/0 (0)
<b>Sex</b>				
Female	122 (49.2)	54 (51.4)	49 (27.3)	8/29 (27.6)
Male	125 (50.4)	51 (48.6)	64 (35.8)	11/36 (30.6)
Unknown/other	1 (0.4)	0 (0)	66 (36.9)	1/6 (16.7)
<b>Race/ethnicity</b>				
Asian	58 (23.4)	26 (24.8)	19 (10.6)	0/7 (0)
Black or African American	10 (4.0)	6 (5.7)	9 (5.0)	3/4 (75.0)
Hispanic or Latino; all races	57 (23.0)	21 (20.0)	39 (21.8)	8/25 (32.0)
Multiracial	5 (2.0)	2 (1.9)	3 (1.7)	0/2 (0)
Native American	1 (0.4)	1 (1.0)	0 (0)	0/0 (0)
Native Hawaiian/other Pacific Islander	4 (1.6)	1 (1.0)	0 (0)	0/0 (0)
Other	7 (2.8)	3 (2.9)	2 (1.1)	0/0 (0)
White	102 (41.1)	45 (42.9)	37 (20.7)	9/25 (36.0)
Unknown	4 (1.6)	0 (0)	70 (39.1)	0/8 (0)
<b>Household size<sup>d</sup></b>				
1	56 (22.6)	N/A	N/A	N/A
2-4	157 (63.3)	95 (90.5)	N/A	N/A
≥5	30 (12.1)	10 (9.5)	N/A	N/A
Unknown	5 (2.0)	N/A	N/A	N/A
<b>Underlying medical conditions<sup>e</sup></b>				
None reported/unknown	184 (74.2)	71 (67.6)	158 (88.3)	18/61 (29.5)
≥1	64 (25.8)	34 (32.3)	21 (11.7)	2/10 (20.0)
<b>Symptoms in last 14 d<sup>f</sup></b>				
None	44 (17.8)	14 (13.3)	92 (51.4)	9/50 (18.0)
Any	203 (81.9)	91 (86.7)	21 (11.7)	9/15 (60.0)
Unknown	1 (0.4)	0 (0)	66 (36.9)	2/6 (33.0)
<b>Vaccination status<sup>g</sup></b>				
Fully vaccinated	248 (100)	105 (100)	101 (56.4)	12/38 (31.6)
Pfizer	150 (60.5)	67 (63.8)	63 (62.4)	4/22 (18.2)
Moderna	39 (15.7)	16 (15.2)	21 (20.1)	0/7 (0)
Janssen (Johnson & Johnson)	59 (23.8)	22 (21.0)	17 (16.8)	8/9 (88.9)
Partially vaccinated	N/A	N/A	27 (15.1)	2/15 (13.3)
Unvaccinated/unknown	N/A	N/A	51 (28.5)	6/18 (33.3)
<b>Lineage (index)<sup>h</sup></b>				
Total sequenced <sup>i</sup>	108 (43.5)	56 (53.3)	52 (29.1)	18/52 (34.6)
Any variants of concern <sup>l</sup>	74 (68.5)	39 (69.6)	32 (61.5)	8/32 (25.0)
B.1.617.2/AY.1 (Delta)	39 (36.1)	20 (35.7)	16 (30.8)	5/16 (33.3)
B.1.1.7 (Alpha)	18 (16.7)	8 (14.3)	8 (15.3)	2/8 (25.0)
P.1 (Gamma)	14 (13.0)	8 (14.3)	3 (5.8)	0/3 (0)

**Table 1. Continued**

Characteristics	No. (%)			
	All Fully Vaccinated Persons With Positive SARS-CoV-2 Test Result	Fully Vaccinated Index Patients Who Named Household Contacts <sup>a</sup>	Household Contacts	Secondary Attack Rate, <sup>b</sup> No. of Household Contacts With Positive Test/No. of Household Contacts Tested (%)
B.1.351 (Beta)	3 (2.8)	3 (5.4)	5 (9.6)	1/5 (20.0)
Any variants of interest <sup>c</sup>	15 (13.9)	6 (10.7)	11 (21.2)	5/11 (45.5)
B.1.526 (Iota)	8 (7.4)	3 (5.4)	9 (17.3)	5/9 (55.6)
B.1.429	3 (2.8)	0 (0)	0 (0)	0/0 (0)
B.1.617.1 (Kappa)	2 (1.9)	2 (3.6)	2 (3.8)	0/2 (0)
B.1.427	1 (0.9)	0 (0)	0 (0)	0/0 (0)
B.1.617.3	1 (0.9)	1 (1.8)	0 (0)	0/0 (0)
Other variants <sup>d</sup>	19 (17.6)	8 (14.3)	9 (17.3)	5/9 (55.6)
B.1.1.318	7 (6.4)	3 (5.4)	5 (9.6)	2/5 (40.0)
A.2.5	3 (2.8)	2 (3.6)	2 (3.8)	2/2 (100.0)
B.1.617	2 (1.9)	1 (1.8)	0 (0)	0/0 (0)
B.1.258	2 (1.9)	1 (1.8)	2 (3.8)	1/2 (50.0)
Not sequenced	140 (56.5)	49 (46.7)	127 (70.1)	2/19 (10.5)

Abbreviations: CDC, Centers for Disease Control and Prevention; IQR, interquartile range; N/A, not applicable; SARS-CoV-2, severe acute respiratory syndrome coronavirus 2.

<sup>a</sup>The 105 index patients are a subset of 248 fully vaccinated patients with breakthrough infection. Households were identified by index patient and confirmed during contact-tracing interviews. Index patients were identified as the patient with the earliest positive SARS-CoV-2 specimen collection date or symptom onset date for each household.

<sup>b</sup>Secondary attack rate based on characteristic of contact.

<sup>c</sup>Persons aged 0–17 years would not have been able to be fully vaccinated during this time frame.

<sup>d</sup>Number of persons in household. Household size data for contacts are not available.

<sup>e</sup>Interviewers asked about medical conditions, including chronic lung, liver, immune, neurodevelopmental, renal, cardiovascular conditions, diabetes, and smoking. Information about childhood obesity and oral health was not collected. Condition-specific data are not shown because of small numbers.

<sup>f</sup>Interviewers asked about signs and symptoms including chills, headache, muscle ache, rhinorrhea, vomiting, abdominal pain, cough, diarrhea, fever, shortness of breath, altered sense of smell or taste, and sore throat.

<sup>g</sup>Partially vaccinated patients were defined as patients who received at least 1 dose of vaccine but were not fully vaccinated. Fully vaccinated patients were defined as patients who had received a second mRNA vaccine dose or a single-dose viral vector vaccine ≥14 days from symptom onset or collection of a positive specimen.

<sup>h</sup>Classified by Pangolin (<https://pangolin.cog-uk.io>) identification of lineage. Whole-genome sequencing of specimens was performed by multiple laboratories.

<sup>i</sup>Sequencing data not available for contacts. Lineages listed for household contacts are based on the lineage identified for the associated index patient.

<sup>j</sup>CDC classification as a variant of concern or variant of interest as of 3 August 2021 (<https://www.cdc.gov/coronavirus/2019-ncov/variants/variant-info.html>).

<sup>k</sup>Five variants each with n = 1 not shown.

(119; 59%), headache (89; 44%), loss of taste or smell (83; 41%), and sore throat (59; 29%). Four fully vaccinated patients were hospitalized, among whom 3 were over the age of 50 and had comorbidities and 2 had received the Johnson & Johnson, 1 had received Pfizer, and 1 had received Moderna vaccine. No COVID-19–related deaths were identified.

**Outcomes of Household Contact Tracing and Secondary Attack Rates**

Among 248 fully vaccinated patients with breakthrough infection, 105 (42%) were identified as the index patients. These patients named 179 household contacts. Overall, 101 (56%) contacts were fully vaccinated, 27 (15%) were partially vaccinated, and 51 (29%) were unvaccinated/unknown (Figure 1). Seventy-one household contacts (40%) were tested for SARS-CoV-2. There was no significant association found between vaccination status and whether a contact was tested ( $P = .18$ ), with 38% of fully vaccinated, 56% of partially vaccinated, and 35% of unvaccinated/unknown contacts undergoing testing for SARS-CoV-2. There was a significant association found between symptom status and whether a fully vaccinated contact was tested ( $P < .00001$ ). Among 101 fully vaccinated contacts, 11 (11%) reported symptoms, 9 (82%) of whom were tested; 51

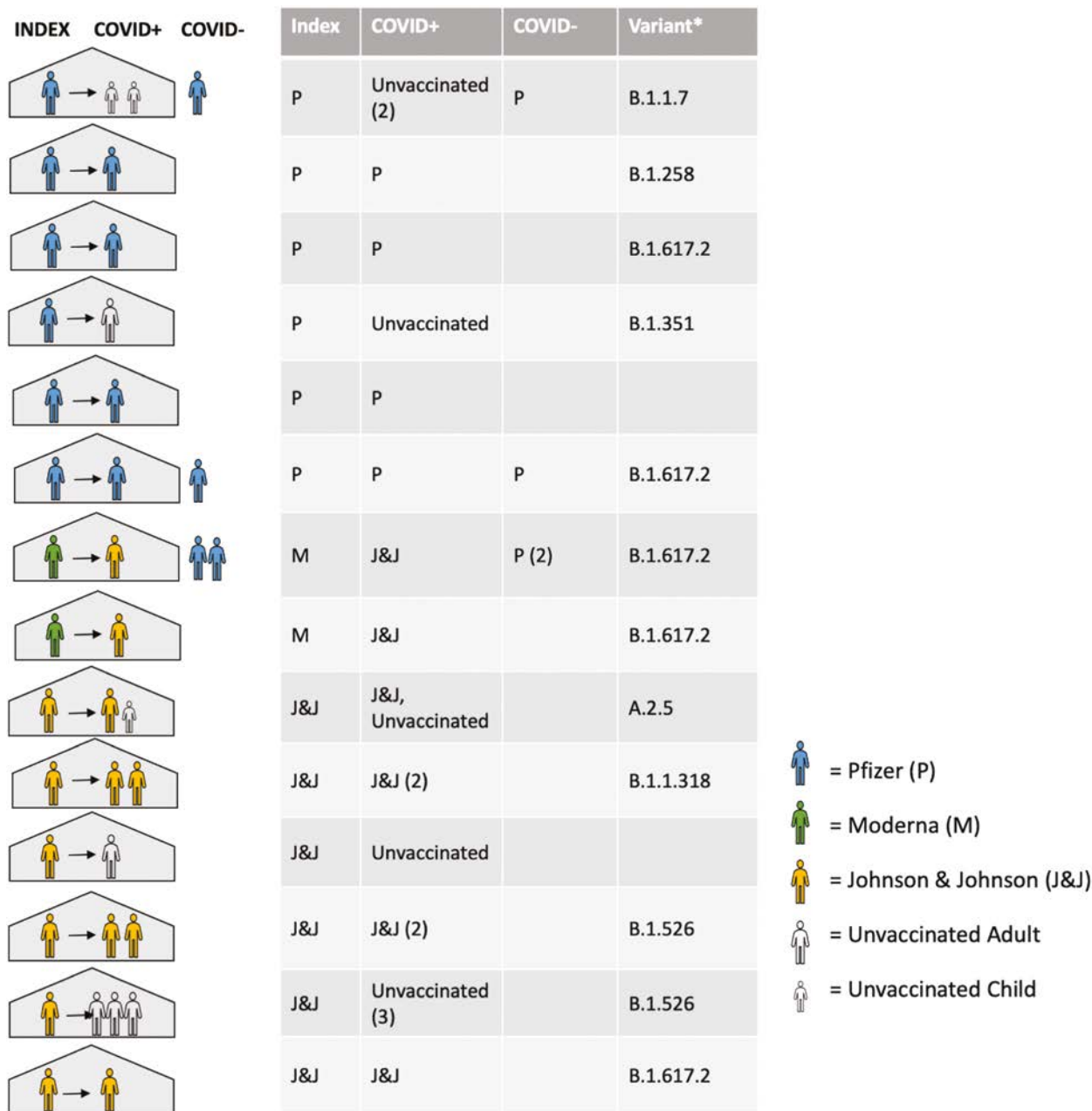
(50%) reported being asymptomatic, 26 (51%) of whom were tested; and 39 (39%) had unknown symptom status, 3 (8%) of whom were tested.

Overall, of 71 tested contacts, 20 tested positive for SARS-CoV-2, resulting in a secondary attack rate of 28%. Among the positive contacts, 12 (32%) were fully vaccinated, 2 (13%) were partially vaccinated, and 6 (33%) were unvaccinated or unknown. Among the 12 fully vaccinated positive contacts, 4 (44%) were symptomatic, 6 (23%) were asymptomatic, and 2 (67%) were unknown.

When conditioned on contact symptom status, the estimated numbers of new cases among fully vaccinated contacts were 4.9 among symptomatic, 11.8 among asymptomatic, and 26 among unknown status, resulting in a secondary attack rate of 42.3%. Secondary attack rates stratified by demographic and clinical covariates of contacts, as well as variant-type exposure, are summarized in the Table 1.

In summary, 20 secondary cases were diagnosed among household contacts of 14 fully vaccinated index patients (Figure 2). In 9 households, the index patient transmitted to 1 contact and in the 5 other households, the index patient transmitted to more than 1 contact. Among 83 index patients who



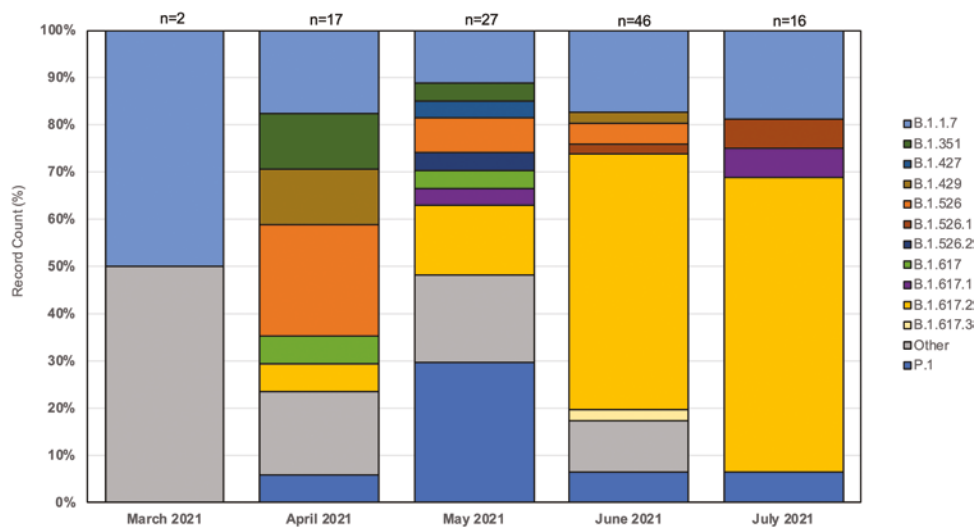


**Figure 2.** Diagram showing transmission from fully vaccinated breakthrough index cases to household contacts by vaccine status and variant type. \*Variant data come from sequencing of index cases. Variant data for secondary cases were not available. Abbreviation: COVID, coronavirus disease 2019.

were fully vaccinated with mRNA vaccine, 8 (10%) transmitted to 3 unvaccinated and 6 fully vaccinated household contacts. In contrast, among 23 index patients who received the Johnson & Johnson vaccine, 6 (27%) transmitted to 5 unvaccinated contacts and 6 vaccinated contacts who had also received the Johnson & Johnson vaccine. No transmission from 14 asymptomatic fully vaccinated index patients to household contacts was observed. In addition, no transmissions were found among tested contacts who had received Moderna ( $n = 7$ ), whereas 8 of 9 contacts who received the Johnson & Johnson and 4 of 22 contacts who received Pfizer vaccine tested positive.

#### SARS-CoV-2 Whole-Genome Sequencing Results and Variant Typing

Whole-genome sequence data were available from 108 (44%) of 248 fully vaccinated persons; 89 (82%) were identified as VOCs (68.5%) or VOIs (13.9%). VOCs included delta (B.1.617.2/AY.1, 36%), alpha (B.1.1.7, 17%), gamma (P.1, 13%), and beta (B.1.351, 3%). The presence of one or more neutralizing antibody escape mutations (L452R, E484Q, and/or E484K) was identified in 77% (83 of 108) patients. [Figure 3](#) demonstrates the shift in the distribution of variants among cases over time, with delta making up 55% of sequenced breakthrough cases by June 2021. Twelve of fourteen index patients who likely



**Figure 3.** Chart showing how the distribution of COVID-19 variants identified among fully vaccinated cases changed over time. Abbreviation: COVID, coronavirus disease 2019.

transmitted to their household contacts had available sequence data (5 delta/ B.1.617.2, 2 B.1.526, 1 beta/ B.1.351, 1 B.1.1.318, 1 A.2.5, 1 alpha/ B.1.1.7, and 1 B.1.258). There were no observed differences in secondary attack rate by variant type, although numbers were small.

## DISCUSSION

These findings indicate that symptomatic fully vaccinated patients with breakthrough infections can transmit the virus to others in their household. Among the 20 secondary cases identified, 9 were fully vaccinated, among whom 6 reported no symptoms. These data support updated CDC guidance from 27 July 2021 recommending that vaccinated persons who have a known exposure to someone with suspected or confirmed COVID-19 get tested 3–5 days after exposure and wear a mask in indoor settings for 14 days or until they receive a negative test result [9]. In addition, while only 29% of contacts were unvaccinated, 33 of 51 (65%) unvaccinated household contacts did not test, underscoring the importance of ongoing messaging and resources to facilitate timely testing for those who are exposed to disease.

Viral genomic sequencing of samples from 44% of fully vaccinated patients showed that 82% were associated with infection by variants of concern (VOCs)/variants of interest (VOIs). Although the frequency of VOC/VOI infections was similar to that in California (89%) during April–May 2021, the prevalence of B.1.1.7 among fully vaccinated patients (17%) was lower than state estimates (59%) [12]. In contrast, from June and July 2021, the prevalence of Delta among fully vaccinated patients reflected contemporaneous state estimates (55% and 86%, respectively) [12]. Unlike Delta, B.1.1.7 is the only VOC/VOI identified that does not contain the E484Q, E484K, or

L452R mutations potentially associated with viral escape from vaccine-induced immunity [13, 14].

Prior to the emergence of Delta, transmission from persons fully vaccinated with mRNA vaccine to other fully vaccinated persons was not observed in our study sample. In June 2021, 6 persons fully vaccinated with mRNA vaccine and infected with Delta transmitted to other household members vaccinated with mRNA vaccine. These findings are consistent with reports of reduced vaccine effectiveness of mRNA vaccine and data from international contact-tracing studies [15–19]. Selective acquisition of certain viral strains over others by fully vaccinated persons may result in selective transmission of these viruses in communities with high vaccination coverage, such as San Francisco [20].

Finally, transmission from 6 (of 23) index patients who had received the Johnson & Johnson vaccine to vaccinated contacts who had also received the Johnson & Johnson vaccine might be the result of the reported reduced effectiveness of the vaccine in preventing infection compared with that of mRNA vaccines [2, 17, 18]. These findings are consistent with accumulating data on the limitations of single-dose Johnson & Johnson vaccine on preventing transmission and support updated recommendations for booster dosing for all persons aged older than 18 years [21].

The findings in this report are subject to at least 6 limitations. First, a small sample of fully vaccinated patients with COVID-19 was identified in a jurisdiction with high vaccination coverage and might underestimate the risk of breakthrough infection compared with areas with lower vaccination rates and higher disease prevalence. Second, although this analysis included 26 fully vaccinated asymptomatic persons who sought testing, such persons would have been excluded from screening based on recommendations during the time period and are under-represented. Results showed a much higher secondary attack



rate among fully vaccinated contacts when taking into account that asymptomatic persons were less likely to be tested. Third, in some households the fully vaccinated patient with COVID-19 might not have been the initial index patient in the household, particularly if the primary patient was asymptomatic or if household members had a shared exposure outside the household that was not identified by the public health investigators. Fourth, it is not possible to meaningfully compare secondary attack rates between vaccinated and unvaccinated contacts since a larger proportion of vaccinated contacts compared with unvaccinated contacts was tested. Fifth, although statistical tests were performed to assess for selection bias in testing of contacts, we were unable to fully account for differential testing recommendations of contacts based on both vaccination and symptom status due to a small sample size and missing symptom data for 37% of contacts. Finally, interviewed patients might have inaccurately reported symptom or vaccination history.

Despite these limitations, these data provide a comprehensive, population-level description of breakthrough infections and secondary transmission in the era before and immediately after the resurgence of COVID-19 due to the Delta variant in the United States. Breakthrough infections made up less than 5% of all cases identified in San Francisco during this study period; however, by July 2021, nearly half of new infections in San Francisco were among fully vaccinated persons. Given the rapid speed of transmission of Delta to contacts and return to pre-pandemic levels of activity, conducting timely contact tracing in order to halt transmission chains will be increasingly challenging [8, 19, 22].

This report found that transmission of SARS-CoV-2 can occur from symptomatic fully vaccinated index patients to both unvaccinated and vaccinated household contacts. These findings reinforce the importance of mitigation measures such as wearing face masks in shared spaces when a member of the household is infected or symptomatic and awaiting test results and timely testing if exposed to disease, regardless of vaccination status. As vaccination coverage expands in the United States, more studies are needed to better understand associated factors and public health implications of transmission from fully vaccinated persons.

## Notes

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All authors have submitted the ICMJE Form for Disclosure of Potential Conflicts of Interest. Conflicts that the editors consider relevant to the content of the manuscript have been disclosed.

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