Impact of the COVID-19 Vaccine on Asymptomatic Infection Among Patients Undergoing Pre-Procedural COVID-19 Molecular Screening

Aaron J. Tande, MD;[1]* Benjamin D. Pollock, PhD, MSPH;[2,3]* Nilay D. Shah, PhD;[3] Gianrico Farrugia, MD;[4] Abinash Virk, MD;[1] Melanie Swift, MD, MPH;[5] Laura Breeher, MD, MPH;[5] Matthew Binnicker, PhD;[6] Elie F. Berbari, MD[1]

*Drs. Tande and Pollock contributed equally to this article.

[1] Division of Infectious Diseases, Mayo Clinic, Rochester, MN, USA;
[2] Department of Quality, Experience, and Affordability, Mayo Clinic, Rochester, Minnesota, USA;
[3] Division of Health Care Delivery Research, Robert D. and Patricia E, Kern Center for the Science of Health Care Delivery, Mayo Clinic, Rochester, Minnesota, USA;
[4] Division of Gastroenterology, Mayo Clinic, Rochester, MN, USA;
[5]Division of Preventive, Occupational Medicine, and Aerospace Medicine, Mayo Clinic, Rochester, MN, USA
[6] Division of Clinical Microbiology, Department of Laboratory Medicine and Pathology, Mayo Clinic, Rochester, MN, USA

Corresponding author:

Aaron J. Tande, M.D.

Division of Infectious Diseases, Mayo Clinic

200 First St. SW, Rochester, MN 55905, USA

507-255-7761

507-255-7767 (fax)

E-mail: tande.aaron@mayo.edu

Summary: Among asymptomatic adults undergoing pre-procedural SARS-CoV-2 molecular screening, the risk of a positive test was lower among those >10 days after 1st dose and >0 days after 2nd dose of an mRNA COVID-19 vaccine, when compared to those who were unvaccinated.

ABSTRACT

Background

Several vaccines are now clinically available under emergency use authorization in the United States and have demonstrated efficacy against symptomatic COVID-19. The impact of vaccines on asymptomatic SARS-CoV-2 infection is largely unknown.

Methods

We conducted a retrospective cohort study of consecutive, asymptomatic adult patients (n = 39,156) within a large United States healthcare system who underwent 48,333 pre-procedural SARS-CoV-2 molecular screening tests between December 17, 2020 and February 8, 2021. The primary exposure of interest was vaccination with at least one dose of an mRNA COVID-19 vaccine. The primary outcome was relative risk of a positive SARS-CoV-2 molecular test among those asymptomatic persons who had received at least one dose of vaccine, as compared to persons who had not received vaccine during the same time period. Relative risk was adjusted for age, sex, race/ethnicity, patient residence relative to the hospital (local vs. non-local), healthcare system regions, and repeated screenings among patients using mixed effects log-binomial regression.

Results

Positive molecular tests in asymptomatic individuals were reported in 42 (1.4%) of 3,006 tests performed on vaccinated patients and 1,436 (3.2%) of 45,327 tests performed on unvaccinated patients (RR=0.44 95% CI: 0.33-0.60; *p<.0001*). Compared to unvaccinated patients, the risk of asymptomatic SARS-CoV-2 infection was lower among those >10 days after 1st dose (RR=0.21;

95% CI: 0.12-0.37; *p*<.*0001*) and >0 days after 2nd dose (RR=0.20; 95% CI: 0.09-0.44; *p*<.*0001*) in the adjusted analysis.

Conclusions

COVID-19 vaccination with an mRNA-based vaccine showed a significant association with a reduced risk of asymptomatic SARS-CoV-2 infection as measured during pre-procedural molecular screening. The results of this study demonstrate the impact of the vaccines on reduction in asymptomatic infections supplementing the randomized trial results on symptomatic patients.

Keywords: COVID-19; SARS-CoV-2; vaccination; Asymptomatic

INTRODUCTION

Since the beginning of the COVID-19 pandemic, more than two million lives have been lost and the global society has been disrupted in an unprecedented manner[1]. Despite significant efforts leveraging nonpharmacologic interventions such as use of face masks, physical distancing, community stay-at-home measures, quarantine, and isolation, spread has continued throughout much of the world. Ongoing infection and subsequent transmission from asymptomatic individuals is a significant contributing factor to the ongoing pandemic, with more than half of all transmission estimated to occur from individuals without symptoms[2]. Disrupting the rate of asymptomatic transmission is critical to bringing the pandemic to an end.

Through an unprecedented global effort at vaccine development, several vaccines have been licensed for use across the world. The data supporting the approval of these vaccines were based on reduction of symptomatic or severe COVID-19 disease. Published results from late-stage clinical trials show that the vaccine efficacy at preventing symptomatic COVID-19 disease ranged from 70.4-95%[3-5]. There is significant uncertainty, however, in the impact of COVID-19 vaccination on asymptomatic SARS-CoV-2 infection and transmission risk. The ability of vaccination to reduce asymptomatic or minimally symptomatic infection will be critical to ending the pandemic, given the relative contribution of asymptomatic infection to viral transmission. There are limited real-world data on the impact of vaccination on asymptomatic SARS-CoV-2 infection, which severely limits the development of post-vaccination behavior recommendations and may contribute to vaccine hesitancy [6].

Within our healthcare system, patients are routinely evaluated for symptomatic and asymptomatic SARS-CoV-2 infection prior to surgery and medical procedures, which have

potential to generate an aerosol. This approach has been in place since April 2020, in an effort to prevent patient harm from operative complications related to COVID-19 and decrease potential exposure and transmission to healthcare personnel [7]. Preoperative evaluation has included patient symptom questionnaires before and upon arrival at our medical facilities, combined with SARS-CoV-2 molecular testing performed just prior to selected medical and surgical procedures. In this study, we sought to evaluate the real-world impact of vaccination on pre-procedural SARS-CoV-2 molecular test positivity among individuals without symptoms and to assess the impact of vaccination on asymptomatic/pre-symptomatic infection.

PATIENTS AND METHODS

Study population

This was a retrospective cohort study that included all consecutive molecular screening tests performed in adult (≥18 years old) patients at Mayo Clinic campuses located in Rochester, MN, Phoenix, AZ, and the Mayo Clinic Health System (located in Minnesota and Wisconsin) who underwent pre-procedural and pre-surgical SARS-CoV-2 molecular testing (henceforth referred to as pre-procedural molecular screening) within 48-72 hours of their procedure. All patients undergoing testing between December 17, 2020 to February 8, 2021 were included. December 17, 2020 was chosen as this was the first date that vaccines were administered at these sites. In the Midwest region (Rochester, MN campus and the Mayo Clinic Health System), criteria for pre-procedural molecular screening was determined by a multidisciplinary COVID-19 Diagnostic Stewardship Committee, with ongoing review on a weekly basis[8]. The Arizona campus uses similar guidance to determine the need for pre-procedural molecular screening. In general, all surgical procedures requiring general anesthesia and other select medical procedures (Supplemental material) required pre-procedural molecular screening. In addition to molecular

screening, patients were asked whether they had fever or other COVID-19 symptoms that were new or not related to a pre-existing condition prior to their surgical procedure through a standardized phone or electronic questionnaire (Supplemental material), as well as when arriving onsite for their procedure. Patients were not followed to assess for development of subsequent symptoms. Patients tested due to symptoms or a known exposure were tested using an alternative ordering process and were excluded from this analysis. This study was deemed exempt by the Mayo Clinic IRB.

Data sources

For this study, all patient-level data from molecular screening tests (including test collection date/time, and Mayo Clinic site), vaccinations (including vaccination manufacturer, date/time, dose, Mayo Clinic site) and patient demographic data (age, sex, race/ethnicity, state of residence) were captured in the electronic health record (EHR) and compiled in an institutionally-curated COVID-19 database housing distinct tables for molecular testing, serology testing, and inpatient COVID-19 data. This database represents the primary, centralized source of COVID-19 data at our institution and is easily accessible through Structured Querying Language (SQL) [9].

Exposure(s)

The primary exposure was vaccination with at least one dose of the BNT162b2 (Pfizer, Inc., New York, NY) or mRNA-1273 (Moderna, Inc., Cambridge, MA) SARS-CoV-2 vaccines prior to molecular screening. We assessed exposure as vaccinated (with any number of doses and at any time interval) prior to SARS-CoV-2 molecular screening versus unvaccinated prior to

screening. We also conducted analyses categorizing patients by timing of vaccination (days from vaccination to screening) as well as by number of doses (0, 1, or 2) prior to screening. We further conducted a subgroup analysis for those receiving the Pfizer vaccine.

Outcome

The outcome was relative risk of a positive test at pre-procedural molecular screening. The period prevalence, more commonly termed percent positivity, was also determined and aggregated by exposure categories. Molecular testing was performed through a combination of emergency use authorized methods depending on the Mayo Clinic location, including a SARS-CoV-2 laboratory-developed real-time PCR [10], the APTIMA SARS-CoV-2 transcription-mediated amplification assay (Hologic, Marlborough, MA), and the Abbott RealTi*m*e SARS-CoV-2 real-time PCR method [11]. When available, we obtained the cycle threshold (Ct) or relative light unit (RLU) values for positive molecular test results. The real-time PCR Ct values are inversely proportional to the amount of viral RNA in the sample, while the RLU values are directly proportional to the concentration of target nucleic acid.

Statistical analysis

Patient demographics including age, sex, race/ethnicity, county and state of residence, and whether the patient resided in the hospital's Health Referral Region (HRR), a proxy for whether or not that patient was 'local', were gathered and compared between those who were vaccinated prior to molecular screening versus those who were unvaccinated at the time of screening using a chi-squared test for sex and state of residence and a t-test for age. We calculated the percent positivity of molecular screening comparing vaccinated and unvaccinated

groups and compared these using log-binomial regression to estimate the unadjusted Relative Risk (RR) and 95% CI.

For patients vaccinated prior to molecular screening, we calculated 'days-to-screening' by subtracting the date of molecular screening from the date of vaccination and plotted Kaplan-Meier survival analysis by number of doses received. Rarely, patients were vaccinated on the same day as their pre-procedure molecular screening. For these patients (n = 151), we considered them to be 'vaccinated' prior to screening and calculated the days-to-screening as zero. We categorized timing as: unvaccinated prior to screening; screening 0-10 days after 1st dose; screening >10 days after 1st dose; screening >0 days after 2nd dose. Finally, we analyzed data based on the number of doses prior to screening. Patients were categorized as having received 0 doses (unvaccinated), 1 dose, or 2 doses. The percent positivity and exact 95% confidence intervals (CI) for these four vaccination groups were calculated and analyzed as described above. We also conducted sub-group analysis by assessing the timing categories described above within patients who received only the BNT162b2 (Pfizer) vaccine. There were not a sufficient number of patients receiving the mRNA-1273 (Moderna) vaccine to perform a sub-group analysis for that group. All analyses were repeated with adjustment in mixed effect models with random intercepts for each Mayo Clinic site (Rochester, MCHS, and Arizona), a random residual to correct for intra-patient repeated measures, and fixed effects for age, sex, race/ethnicity, and patient residence relative to the hospital (local vs. non-local).

RESULTS

There were 48,333 molecular screening tests performed among 39,156 unique patients during the study period. Mean (SD) age was 54.2 (19.7) years and 25,364 (52.5%) were female. There were 3,006 (6.2%) screening tests performed on individuals who were vaccinated prior to their

molecular screening (**Table 1**). Those who were vaccinated were significantly younger and more likely to be female than those without prior vaccination reflecting the early focus on vaccinating health care workers. We observed differences in the race, state of residence and residence within the local HRR. Among the vaccinated group, median (IQR) time from first dose of vaccine to their molecular screening was 16 days (7 days, 27 days), with 707 (23.5%) screening tests in the vaccinated group having occurred among individuals who had received their second dose.

Among 45,327 screening tests performed on unvaccinated individuals without COVID-19 symptoms, 1,436 (3.2%; 95% CI: 3.0%-3.3%) were positive. Among 3,006 screening tests performed on patients without COVID-19 symptoms who had received at least one dose of vaccine prior to molecular screening, 42 (1.4%; 95% CI: 1.0%-1.8%) were positive. The cumulative percent positive six weeks after the first dose of vaccine in those receiving 1 versus 2 doses was 2.9% and 1.3%, respectively (**Figure 1**).

In our primary analysis, the unadjusted Relative Risk (RR) for a positive test during asymptomatic pre-procedure screening comparing vaccinated versus unvaccinated was 0.44 (95% CI: 0.33-0.60; *p<.0001;* **Table 2**). The RR for a positive test comparing screening >10 days after 1st dose to unvaccinated was 0.28 (95% CI: 0.16-0.49; *p<.0001*), and the RR for a positive test comparing screening >0 days after 2nd dose to unvaccinated was 0.27 (95% CI: 0.12-0.60; *p=.001*). In the number of doses analysis, the RR for a positive test comparing 1 dose to unvaccinated was 0.49 (95% CI: 0.36-0.69; *p<.0001*) and the RR for a positive test comparing 2 doses to unvaccinated was 0.27 (95% CI: 0.12-0.60; *p=.001*).

After adjustment for confounding variables and random effects, the adjusted Relative Risk (aRR) for a positive test during asymptomatic pre-procedure screening comparing

vaccinated versus unvaccinated was 0.35 (95% CI: 0.26-0.47; *p<.0001;* **Figure 2**). The aRR for a positive test comparing screening >10 days after 1st dose to unvaccinated was 0.21 (95% CI: 0.12-0.37; *p<.0001*), and the aRR for a positive test comparing screening >0 days after 2nd dose to unvaccinated was 0.20 (95% CI: 0.09-0.44; *p<.0001*). Further analysis, including in the Pfizer-only subgroup analysis, remained significant after adjustment (**Figure 2**).

The molecular tests' Ct or RLU values were available for 38 (90.5%) of 42 and 1,116 (77.7%) of 1,436 positive screening tests in the vaccinated and unvaccinated groups, respectively (Supplemental Material, Table S1 and Table S2). Multiple different testing methods were used in these patients, limiting the comparison between vaccinated and unvaccinated groups to only those tested using the same method. Interestingly, the Ct values of positive results from vaccinated individuals at our Arizona location were significantly lower ($p < 0.01$) than for unvaccinated individuals, but there were no other significant differences. Among positive tests in Arizona, there was a non-significant difference in the Ct value when analyzed by timing after vaccination (Supplemental Material, Table S2).

DISCUSSION

In this real-world study, we observed that vaccination using an mRNA COVID-19 vaccine is associated with a reduced rate of asymptomatic SARS-CoV-2 infection among individuals tested during pre-procedural molecular screening. We observed a significant decrease in asymptomatic infection, consistent in timing and magnitude with what has been observed in clinical trials evaluating the prevention of symptomatic infection after vaccination with mRNA vaccine[3, 4]. Among individuals who had received a single dose of vaccine >10 days prior to their pre-procedure test, we observed a 72% reduction in the risk of a positive molecular screening test. When analysis was limited to those individuals who received two

doses of vaccine, we observed a 73% reduction in the risk of a positive molecular screening test compared to those who were not vaccinated. After adjustment for multiple potential confounding factors, we observed an 80% reduction in the risk of a positive molecular screening test among test performed in persons who had received 2 doses of vaccine, compared to those who were not vaccinated.

There are mixed data from published clinical trials regarding efficacy of vaccination against asymptomatic infection. During the clinical trial to approve the mRNA-1273 vaccine (Moderna), SARS-CoV-2 PCR was performed in asymptomatic individuals 28 days from the first dose, just prior to the second dose [3]. That study observed a 62% reduction in the risk of asymptomatic infection in the vaccine group (14 of 14,550, 0.10%), compared to the placebo group (39 of 14,598, 0.27%). In our study, the majority (94%) of patients received the BNT162b2 mRNA vaccine (Pfizer) with a smaller number receiving the mRNA-1273 vaccine (5.9%). In the subgroup analysis of those more than 10 days after their first dose of the BNT162b2 mRNA vaccine, we observed a 79% reduction in risk of a positive test, after adjustment for potential confounding factors. Our observation of a similar reduction in risk among individuals >10 days after the first vaccine dose who predominantly received the BNT162b2 vaccine suggests that both mRNA vaccines lead to early reduction in asymptomatic infection soon after the initial dose. Among those individuals receiving both doses of the BNT162b2 vaccine, we observed an 80% reduction in the risk of molecular test positivity, as compared to unvaccinated individuals, after adjustment for potential confounding factors. Compared to the clinical trial efficacy results reported for the BNT162b2 and mRNA-1273 vaccines[3, 5], this reduction in efficacy is not unexpected, given that 36% of post-second dose tests were performed fewer than seven days after their second dose of vaccine.

The impact of vaccine on asymptomatic SARS-CoV-2 infection is likely to be dependent on the efficacy of the specific vaccine. As an example, a single standard dose of the ChAdOx1 nCoV-19 vaccine (Astra Zeneca) did not provide consistent protection against asymptomatic infection [12]. In an analysis performed from 22-90 days after the first vaccine dose, there was no protection against asymptomatic infection. However, among individuals who received two doses of vaccine 12 or more weeks apart, there was a 47% reduction in asymptomatic infection when measured ≥14 days after the second dose. Reduction in asymptomatic infection is also likely impacted by timing of vaccine doses. Analyses similar to the one conducted in our study will be needed to better understand the real-world impact for other vaccines as they receive authorization in the US.

There are several limitations to this study. First, there may have been unmeasured confounding factors that contributed to the lower rate of molecular test positivity within the group that received vaccination. Accordingly, one can only infer correlation between vaccination and reduced molecular test positivity, rather than causation. For most of the observation period, vaccine availability was limited to healthcare personnel and residents of long-term care facilities, due to the increased risk for COVID-19 exposure in these populations. However, one would not be surprised to find higher rates of test positivity in preprocedural screening of these groups; the fact that lower positivity rates were seen in the vaccinated cohort supports a significant mitigating effect of vaccination. We attempted to adjust for confounding factors through an adjusted analysis and observed that the strength of association between vaccine receipt and a decline in test positivity only strengthened. Nevertheless, it is possible that unmeasured confounders remain and contributed to our observations. This study was performed in a largely White, non-Hispanic population that was under the age of 65. A second limitation is

that patients undergoing pre-procedural molecular screening may have been symptomatic or in the pre-symptomatic phase of COVID-19 infection. We relied upon our existing clinical mechanisms to exclude tests ordered on symptomatic patients from this analysis. Some individuals may have not responded to the pre-visit phone call or electronic questionnaire or the personnel asking the questions may not have asked all of the questions. Patients may have not been truthful in their responses. We did not longitudinally follow these patients to assess for development of subsequent symptoms. Therefore, our results may reflect a combination of asymptomatic and mildly symptomatic cases. We attempted to address this limitation by only including patients who underwent testing ordered via an order panel performed for pre-procedure molecular testing, as well as through the existing pre-procedure symptom questionnaire process to identify patients who were symptomatic. Patients who were identified as symptomatic on questionnaire would have been tested through a separate process and excluded from this analysis. Finally, the likely enrichment of the vaccinated cohort with healthcare personnel and long-term care residents could have impacted the rate with which vaccinated subjects reported mild symptoms at the time of preprocedural testing, in which case they would be tested under the symptomatic testing process and not analyzed in this study. The likelihood of false-positive molecular testing was not addressed in this study. While affecting both groups a floor effect may have resulted in an underestimate in the reduction in asymptomatic test positive persons in the vaccinated group as the unadjusted test positivity post vaccination falls within the range of the published molecular test false positivity.

In summary, previous receipt of an mRNA COVID-19 vaccine was associated with an 80% reduction of risk in asymptomatic COVID-19 in patients that have received 2 vaccines when compared to those who had not been vaccinated. These results are consistent with previously published data showing a reduction in asymptomatic infection following vaccination with an mRNA vaccine, even after one dose [3]. From a public health perspective, it will be important to determine if the current recommendations to maintain pre-vaccination behaviors for masking and social distancing will impact vaccine hesitancy. These data together with further studies will inform on the risk benefit balance of current post vaccination guidelines.

FUNDING: This work was supported by internal funding at the Mayo Clinic.

Potential conflicts of interest: M.J.B. reports personal fees from DiaSorin Molecular as an advisory board member, outside the submitted work. In the past 36 months, N.D.S. has received research support through Mayo Clinic from the Food and Drug Administration to establish Yale-Mayo Clinic Center for Excellence in Regulatory Science and Innovation (CERSI) program (U01FD005938); the Centers of Medicare and Medicaid Innovation under the Transforming Clinical Practice Initiative (TCPI); the Agency for Healthcare Research and Quality (R01HS025164; R01HS025402; R03HS025517; K12HS026379); the National Heart, Lung and Blood Institute of the National Institutes of Health (NIH) (R56HL130496; R01HL131535; R01HL151662); the National Science Foundation; and the Patient Centered Outcomes Research Institute (PCORI) to develop a Clinical Data Research Network (LHSNet). All other authors report no potential conflicts of interest. All authors have submitted the ICMJE Form for Disclosure of Potential Conflicts of Interest.

REFERENCES

1. WHO Coronavirus Disease (COVID-19) Dashboard. World Health Organization. https://covid19.who.int/. Accessed February 12, 2021.

2. Johansson, M.A., et al., *SARS-CoV-2 Transmission From People Without COVID-19 Symptoms.* JAMA Netw Open, 2021. **4**(1): p. e2035057.

3. Baden, L.R., et al., *Efficacy and Safety of the mRNA-1273 SARS-CoV-2 Vaccine.* N Engl J Med, 2021. **384**(5): p. 403-416.

4. Polack, F.P., et al., *Safety and Efficacy of the BNT162b2 mRNA Covid-19 Vaccine.* N Engl J Med, 2020. **383**(27): p. 2603-2615.

5. Voysey, M., et al., *Safety and efficacy of the ChAdOx1 nCoV-19 vaccine (AZD1222) against SARS-CoV-2: an interim analysis of four randomised controlled trials in Brazil, South Africa, and the UK.* Lancet, 2021. **397**(10269): p. 99-111.

6. Amit, S., et al., *Post-Vaccination COVID-19 among Healthcare Workers, Israel.* Emerg Infect Dis, 2021. **27**(4).

7. Storino, C.B., et al., *Revamping Outpatient Care for Patients Without COVID-19.* Mayo Clin Proc, 2020. **95**(9S): p. S44-S46.

8. Shah, A.S., et al., *Diagnostic Stewardship: An Essential Element in a Rapidly Evolving COVID-19 Pandemic.* Mayo Clin Proc, 2020. **95**(9S): p. S17-S19.

9. Pollock, B.D., et al., *Deployment of an Interdisciplinary Predictive Analytics Task Force to Inform Hospital Operational Decision-Making During the COVID-19 Pandemic.* Mayo Clinic Proceedings, 2020.

10. Rodino, K.G., et al., *Evaluation of Saline, Phosphate-Buffered Saline, and Minimum Essential Medium as Potential Alternatives to Viral Transport Media for SARS-CoV-2 Testing.* J Clin Microbiol, 2020. **58**(6).

11. Challener, D.W., et al., *Low Utility of Repeat Real-Time PCR Testing for SARS-CoV-2 in Clinical Specimens.* Mayo Clin Proc, 2020. **95**(9): p. 1942-1945.

12. Voysey, M., et al., *Single Dose Administration, And The Influence Of The Timing Of The Booster Dose On Immunogenicity and Efficacy Of ChAdOx1 nCoV-19 (AZD1222) Vaccine*. Preprint available at SSRN: https://papers.ssrn.com/sol3/papers.cfm?abstract_id=3777268

TABLES

Table 1 – Study population characteristics by vaccination status prior to pre-procedure molecular COVID-19 screening

	Screenings with at least 1 prior vaccination n=3,006 (6.2%)	Screenings with no prior vaccination n=45,327 (93.8%)	p-value*
Mayo Clinic Site			<.001
Arizona Campus	1,467 (48.8%)	15,662 (34.6%)	
Rochester Campus	1,005 (33.4%)	15,450 (31.4%)	
Mayo Clinic Health System	534 (17.8%)	14,215 (31.4%)	
Age in years (mean, SD)	46.9(14.9)	55.2(18.4)	<.001
Sex			<.001
Male	1,057 (35.2%)	21,912 (48.3%)	
Female	1,949 (64.8%)	23,415 (51.7%)	
Race			<.001
White, non-Hispanic	2,401 (79.9%)	39,145 (86.4%)	
African or African-American	52 (1.7%)	1,014 (2.2%)	
Asian or Asian-American	184 (6.1%)	1,041 (2.3%)	
Hispanic of any race	180 (6.0%)	2,238 (4.9%)	
Other/Unknown	189 (6.3%)	1,889 (4.2%)	
Patient resides in local HRR	2,537 (84.4%)	28,480 (62.8%)	<.001
State of Residence			<.001
Minnesota	1,227 (40.8%)	18,170 (40.3%)	
Wisconsin	299 (10.0%)	5,988 (13.3%)	
Iowa	20 (0.7%)	1,867 (4.1%)	
Arizona	1,405 (46.7%)	13,824 (30.6%)	
Other	55 (1.8%)	5,478 (12.1%)	
Timing (days to screening)			-
0-10 days after 1st dose	937 (31.2%)	-	
>10 days after 1st dose, before 2nd dose	1,362 (45.3%)	-	
>0 days after 2nd dose	707 (23.5%)	-	
Timing, days to screening, median (IQR)		-	-

Days after 1st dose Days after 2nd dose	16 (7, 27) 9 (5,15)		
Number of doses 1 2	 2,299 (76.5%) 707 (23.5%)	-	
Manufacturer Pfizer Moderna Missing/Unknown/External	 2,826 (94.0%) 178 (5.9%) 2 (<0.1%)	-	

*t-test for continuous variables, chi-squared for categorical variables, and Bonferroni-corrected for multiplicity

Table 2 – Outcomes

	Unadjusted molecular test percent % positivity (95% Confidence Interval)	Unadjusted Relative Risk (95% Confidence Interval)	p-value
Analysis 1			
Unvaccinated (*reference*)	3.1% (3.0%-3.3%)	REF	
At least one vaccination prior to screening	1.4% (1.0%-1.8%)	0.44 (0.33-0.60)	<.0001
Analysis 2			
Unvaccinated (*reference*)	3.1% (3.0%-3.3%)	REF	
Screening 0-10 days after 1st dose	2.6% (1.6%-3.6%)	0.81 (0.54-1.20)	.29
Screening >10 days after 1st dose, before 2nd dose	0.9% (0.4%-1.4%)	0.28 (0.16-0.49)	<.0001
Screening >0 days after 2nd dose	0.9% (0.3%-1.8%)	0.27 (0.12-0.60)	<.0001
Analysis 3			
Unvaccinated (*reference*)	3.1% (3.0%-3.3%)	REF	
1 dose prior to screening	1.6% (1.1%-2.1%)	0.49 (0.36-0.69)	<.0001
2 doses prior to screening	0.9% (0.2%-1.5%)	0.27 (0.12-0.60)	.001
Analysis 4 - Pfizer only			
Unvaccinated (*reference*)	3.1% (3.0%-3.3%)	REF	
Screening 0-10 days after 1st dose	2.7% (1.6%-3.8%)	0.86 (0.58-1.30)	.48
Screening >10 days after 1st dose, before 2nd dose	0.9% (0.4%-1.4%)	0.27 (0.15-0.49)	<.0001
Screening >0 days after 2nd dose	0.9% (0.2%-1.5%)	0.27 (0.12-0.60)	.001

FIGURE LEGENDS

Figure 1- Survival analysis by time-to-pre-procedure positive COVID-19 test after receiving first dose of vaccination, by total doses received

Legend: A person who received their first dose of vaccine on 1/1/2021, their second dose on 1/24/2021, and then had a positive molecular COVID-19 test on 1/26/2021 would appear on both the red (1 dose) and blue (2 dose) lines with the event on day 25 on the x-axis (event occurred 25 days after first dose).

Figure 2 - Adjusted Relative Risk (with 95% Confidence Intervals) comparing pre-procedure COVID-19 molecular screening percent positive by vaccination status and timing

**significant at p<0.001 level*

Legend: RR adjusted for age, sex, race/ethnicity, and patient residence in hospital Health Referral Region (local vs. non-local).

Figure 1

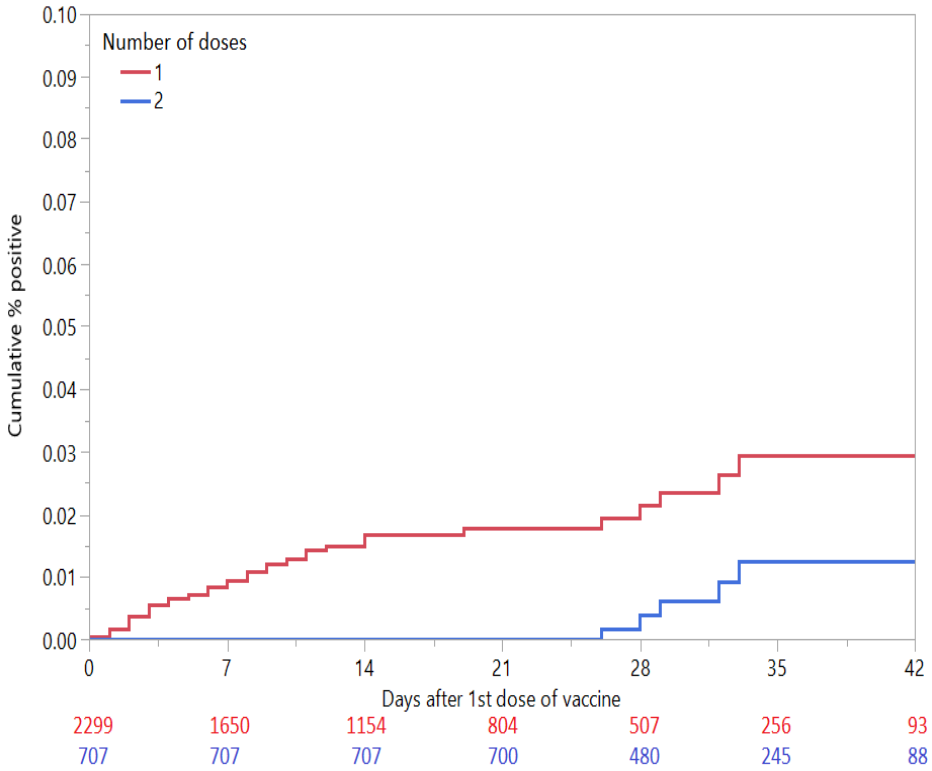

Figure 2