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MAJOR ARTICLE

Description of Hospitalizations due to the Severe Acute Respiratory Syndrome Coronavirus 2 Omicron Variant Based on Vaccination Status

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Background. Limited descriptive data exist regarding the clinical characteristics of hospitalizations due to the severe acute respiratory syndrome coronavirus 2 Omicron variant based on vaccination status.

Methods. This was a retrospective cohort study of all patients hospitalized with a diagnosis of coronavirus disease 2019 (COVID-19) between 15 January 2022 and 15 February 2022 across 9 hospitals in a large health network. Data were extracted by manual records review.

Results. A total of 351 of 452 (77.7%) unvaccinated, 209 of 331 (63.1%) fully vaccinated, and 107 of 163 (65.6%) boosted patients hospitalized with a COVID-19 diagnosis were determined to be admitted specifically due to COVID-19 ($P < .001$). Most (85%) boosted patients admitted due to COVID-19 were at least 65 years old and/or had severe immunosuppression, compared to 72.2% of fully vaccinated and 60.7% of unvaccinated patients ($P < .001$). Significantly more unvaccinated patients (34.2%) required >6 L/minute of supplemental oxygen compared to fully vaccinated (24.4%) and boosted (25.2%) patients ($P = .027$). The age-adjusted vaccine effectiveness (VE) against hospitalization due to COVID-19 was estimated to be 81.1% and 94.1% for full vaccination and boosted status, respectively, whereas VE against mortality related to COVID-19 was estimated to be 84.7% and 94.8%, respectively.

Conclusions. During the Omicron BA.1 sublineage wave, unvaccinated patients hospitalized with a COVID-19 diagnosis were more likely than vaccinated patients to be admitted specifically due to COVID-19. Despite being younger with fewer comorbidities, unvaccinated patients required higher levels of care. Vaccination with a booster provides the greatest protection against hospitalization and death from COVID-19.

Keywords. COVID-19; hospitalization; Omicron; SARS-CoV-2; vaccination.

Vaccination against severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) is an important public health tool to reduce the risk of severe disease caused by coronavirus disease 2019 (COVID-19). Since the emergence of the Omicron (B.1.1.529) variant, substantial escape from neutralizing antibodies induced by vaccination has been reported, particularly in individuals who have not received a booster dose [1]. This has resulted in observational data showing a reduction in vaccine effectiveness (VE) against symptomatic infection [2]. Fortunately, despite a reduction in protection against infection, VE against severe disease remains mostly preserved [3–7]. These studies also highlight the importance of a booster dose to optimize VE against Omicron. A booster dose has also been shown to restore VE against invasive mechanical ventilation (IMV) and death to levels seen against prior variants of concern (VOCs) [8].

Compared to prior VOCs, the Omicron variant may be associated with less severe disease risk to an individual [9, 10]. Despite this finding of reduced disease severity, record hospitalizations occurred in the United States (US) from COVID-19 in January 2022 when the Omicron variant BA.1 sublineage constituted nearly all new cases [11]. However, limited descriptive data exist of hospitalizations from COVID-19 due to the Omicron variant [12]. In particular, there has been much public debate regarding how COVID-19 hospitalizations are classified—whether someone is hospitalized due to COVID-19 or admitted for an unrelated reason and diagnosed incidentally with COVID-19 [13, 14]. This is often difficult to ascertain from electronic data extraction without manual records review.

We previously reported the clinical findings of postvaccination hospitalizations from COVID-19 prior to the use of

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booster doses in our large health network in western Pennsylvania during a 6-week period of the Delta (B.1.617.2) wave [15]. We estimated that 73% of admissions were due to symptomatic COVID-19 infections, and found that most (89.2%) fully vaccinated patients hospitalized due to COVID-19 were ≥65 years old and/or severely immunosuppressed. In this current study, we report the clinical findings of hospitalizations during the Omicron variant BA.1 sublineage wave based on vaccination status.

METHODS

We conducted a retrospective cohort study of all patients admitted with COVID-19 to 9 diverse western Pennsylvania hospitals, including both tertiary care and community-based hospitals, within the Allegheny Health Network (AHN) between 15 January 2022 and 15 February 2022. Exempt status was granted by the AHN Institutional Review Board. Patients were identified using the electronic health record (EHR) by extracting all patients with a positive SARS-CoV-2 test during the study time period, or if they had an active COVID-19 designation by the AHN infection prevention department for patients diagnosed outside the health system. Patients were included if they had COVID-19 during their hospitalization. Patients were excluded for age <18 years, unknown vaccination status, vaccination with a vaccine not authorized for use in the US, or if they were admitted to an outside hospital (OSH) for >48 hours prior to transfer to an AHN facility. Patients are not routinely tested for SARS-CoV-2 on admission at AHN, but only tested per the discretion of the treating clinician, if a long-term care facility protocol requires testing prior to placement, or if a department protocol requires testing prior to a procedure. For patients with multiple hospitalizations, each admission was reviewed. Demographic information, vaccination data, comorbidities, and clinical data were manually collected via review of the EHR, utilizing a standardized data collection instrument.

Each admission was manually reviewed by a study investigator to make a determination if the admission was due to COVID-19 or if the patient was diagnosed incidentally and admitted for an unrelated reason. Admissions were considered due to COVID-19 if a study investigator determined that COVID-19 played any role in the events causing a patient to present for care and/or the clinician(s) caring for the patient documented that the patient was admitted for COVID-19. When this determination was unclear, the primary study investigator reviewed details of the case with a second study investigator blinded to the patient's vaccination status, who then made the determination.

The primary aim was to describe the characteristics of persons admitted with COVID-19 based on vaccination status during a time period when nearly all cases in the US were due to the Omicron variant. Secondary aims included determining estimated SARS-CoV-2 VE against hospitalization from COVID-19, need for intensive care unit (ICU)–level care, IMV, all-cause mortality, and COVID-19–related mortality. VE was estimated using the formula [(attack rate unvaccinated – attack rate vaccinated) / (attack rate unvaccinated)] × 100 using population vaccination data provided by the Pennsylvania Department of Health and Allegheny County Health Department [16, 17]. Mortality was defined as death during hospitalization or within 30 days of admission.

SARS-CoV-2 vaccination status was recorded, including the specific vaccine type (messenger RNA [mRNA]–1273 [Moderna], BNT162b2 [Pfizer-BioNTech], or Ad.26.COV2.S [Janssen]) with vaccination dates. Patients were considered fully vaccinated if symptom onset or positive SARS-CoV-2 testing was at least 14 days after their final dose of a primary series and they did not receive a booster dose. Patients were considered boosted immediately after receipt of an additional vaccine dose with either mRNA-1273 or BNT162b2 that occurred at least 2 months after a dose of Ad.26.COV2.S or 5 months after an mRNA vaccine, consistent with Centers for Disease Control and Prevention guidance [18]. Severe immunosuppression was defined as use of chronic immunosuppressive therapy (if corticosteroids, equivalent of >20 mg prednisone daily), human immunodeficiency virus with CD4 cell count <350 cells/μL, active malignancy with receipt of chemotherapy within the past year, or prior solid organ transplant or hematopoietic stem cell transplantation.

For comparison of continuous variables between 3 groups, nonnormal distribution was assumed and assessed using the Kruskal-Wallis rank-sum test. Days from last vaccine receipt to admission was assessed using the Wilcoxon rank-sum test given nonnormal distribution between the fully vaccinated and boosted groups. Differences between categorical variables were assessed using the χ^2 test or Fisher exact test as appropriate. $P < .05$ was considered statistically significant. Statistical analysis was performed using R version 3.5.1 software (R Foundation for Statistical Computing, Vienna, Austria).

RESULTS

A total of 1089 patients were hospitalized with COVID-19 during the analysis period. Of those, 107 were excluded for the following reasons: 87 had an unknown vaccination status, 13 were <18 years of age, 5 were admitted to an OSH for >48 hours prior to transfer, and 2 received a vaccine not authorized in the US (Figure 1). There were 452 unvaccinated patients, 331 fully vaccinated patients who only completed a primary series, and 163 boosted patients admitted with a COVID-19 diagnosis, of which 351 (77.7%), 209 (63.1%), and 107 (65.6%), respectively, were determined to be admitted due to COVID-19 ($P < .001$). Another 36 patients were only partially vaccinated and not included in data analysis. No patient in this study received a

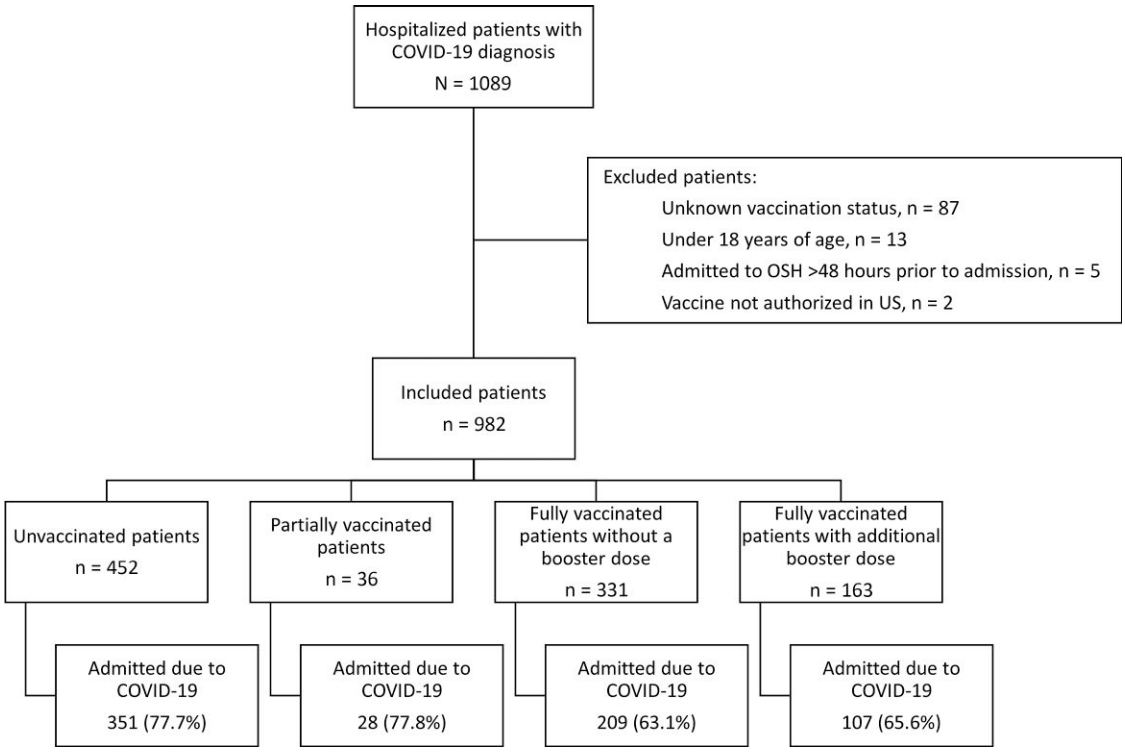

Figure 1. Patient screening. Abbreviations: COVID-19, coronavirus disease 2019; OSH, outside hospital; US, United States.

second booster vaccine dose. The most common reasons for a COVID-19 diagnosis in hospitalizations determined to be non–COVID-19–related for unvaccinated, fully vaccinated, and boosted persons, respectively, were the following: tested during initial workup but admitted for an unrelated cause (40%, 43%, and 41%), testing for placement into another facility (26%, 34%, 27%), and having a recent outpatient diagnosis of COVID-19 but requiring admission for an unrelated cause (29%, 17%, 25%). Other less common reasons for COVID-19 diagnoses included preprocedure testing and nosocomial exposure.

Baseline demographics and comorbidities of patients admitted due to COVID-19 can be found in Tables 1 and 2. Unvaccinated patients were significantly younger with fewer comorbidities. There were 17.1% of unvaccinated patients aged <50 years, compared to 7.2% of fully vaccinated and 4.7% of boosted patients ($P < .001$). Boosted patients were the oldest and had the highest rates of severe immunosuppression. We found that 85% of boosted patients were at least 65 years old and/or had severe immunosuppression, compared to 72.2% of fully vaccinated and 60.7% of unvaccinated patients ($P < .001$). All 3 groups had similar low rates of prior documented infection with SARS-CoV-2. Eleven of the 12 pregnant patients admitted due to COVID-19 were unvaccinated. More patients in the fully vaccinated group completed their primary series with Ad.26.COV2.S compared to those boosted (11% vs 2.8%, $P < .001$). Fully vaccinated patients had a median of 280 days between last vaccine dose and admission compared to 90 days for boosted patients ($P < .001$).

Clinical characteristics of patients admitted due to COVID-19 can be found in Table 3. The median length of stay was similar among the 3 groups. All 3 groups had similar rates of pulmonary symptoms, but 34.2% of unvaccinated patients required >6 L/minute of supplemental oxygen via nasal cannula, which was significantly higher than the 24.4% of fully vaccinated and 25.2% of boosted patients ($P = .027$). Although not statistically significant, unvaccinated patients had the highest rate of ICU-level care. Of the 13 patients aged <50 years who required ICU-level care, 12 were unvaccinated. Mortality rates were similar between the 3 groups. All 4 deaths that occurred in patients aged <50 years were among unvaccinated patients.

Estimations of VE against hospitalization from COVID-19, need for ICU care, IMV, and mortality by different age groups can be found in Table 4. The age-adjusted VE against hospitalization from COVID-19 for the entire cohort was estimated to be 81.1% and 94.1% for full vaccination and boosted status, respectively, while VE against mortality related to COVID-19 was estimated to be 84.7% and 94.8%, respectively.

DISCUSSION

During this study period, a record number of COVID-19 hospitalizations occurred in the US [11]. However, limited

Table 1. Baseline Demographics of Patients Admitted due to Coronavirus Disease 2019

Characteristic	Unvaccinated (n = 351)	Fully Vaccinated (n = 209)	Boosted (n = 107)	*P* Value
Age, y, median (IQR)	67 (56–76)	70 (61–79)	72 (64–84)	**<.001**
<29	17 (4.8)	2 (1)	0	**.004**
30–39	19 (5.4)	4 (1.9)	1 (0.9)	**.031**
40–49	24 (6.8)	9 (4.3)	4 (3.7)	.338
50–59	52 (14.8)	25 (12)	8 (7.5)	.126
60–69	84 (23.9)	63 (30.1)	30 (28)	.254
70–79	89 (25.4)	55 (26.3)	28 (26.2)	.964
≥80	66 (18.8)	51 (24.4)	36 (33.6)	**.005**
Gender, female	191 (54.6)	104 (49.8)	41 (38.3)	**.014**
Race/ethnicity				.313
White	306 (87.2)	194 (92.8)	100 (93.5)	
Black	36 (10.3)	14 (6.7)	6 (5.6)	
Hispanic	3 (0.9)	1 (0.5)	0	
Asian/Pacific Islander	2 (0.6)	0	1 (0.9)	
Other/unknown	4 (1.1)	0	0	
Documented prior infection with SARS-CoV-2	16 (4.6)	11 (5.3)	7 (6.5)	.71
Primary vaccine series				**.018**
BNT162b2	…	119 (56.9)	73 (68.2)	
mRNA-1273	…	67 (32.1)	31 (29)	
Ad.26.COV2.S	…	23 (11.0)	3 (2.8)	
Booster dose				
BNT162b2	…	…	77 (72)	
mRNA-1273	…	…	30 (28)	
Days from last vaccine dose to admission, median (IQR)	…	280 (228–314)	90 (65–111)	**<.001**

Data are presented as No. (%) unless otherwise indicated. *P* values with bold font indicate statistical significance.

Abbreviations: IQR, interquartile range; mRNA, messenger RNA; SARS-CoV-2, severe acute respiratory syndrome coronavirus 2.

descriptive data exist regarding the clinical characteristics of these hospitalizations based on vaccination status, as well as how many patients were admitted either due to COVID-19 or incidentally found to have COVID-19 while being admitted for an unrelated cause. Prior to the Omicron wave (and mostly prior to the Delta wave), an estimated 60%–84% of 1123 COVID-19 hospitalizations across 4 US centers were determined to be admissions specifically for COVID-19 [19]. During a 6-week period of the Delta wave prior to booster doses, our center estimated that 73% of postvaccination admissions were due to symptomatic COVID-19 infections [15]. Of 131 admissions to a Los Angeles, California, center during the early Omicron wave, an estimated 80.2% were likely due to COVID-19 [12]. In this study during the Omicron variant BA.1 sublineage wave, we report the largest manually retrieved data set to our knowledge reporting admissions due to COVID-19, and found that unvaccinated patient admissions were significantly more likely to be due to COVID-19 compared to vaccinated patient admissions. We estimated that 77.7%, 63.1%, and 65.6% of admissions were due to COVID-19 in unvaccinated, fully vaccinated, and boosted individuals, respectively. These findings are likely a result of vaccination leading to higher rates of asymptomatic and paucisymptomatic infection [20], which could explain why the proportion of non–COVID-19–related hospitalizations would be higher in vaccinated individuals. As more of the population gets vaccinated, these data are important to help contextualize how often postvaccination hospitalizations are actually incidental and not a failure of vaccination against severe disease.

We found that patient characteristics of hospitalized patients also differed based on vaccination status. Boosted individuals were the oldest with the highest rates of severe immunosuppression. We found that 85% were at least 65 years old and/or had severe immunosuppression, compared to 72.2% of fully vaccinated and 60.7% of unvaccinated patients. This was not an unexpected finding since vaccination, especially with a booster dose, significantly reduces the risk of severe disease from the Omicron variant, though highly vulnerable people may still be at risk [3–8]. We estimated the age-adjusted VE against hospitalization for the entire cohort to be 81.1% and 94.1% for full vaccination and boosted status, respectively. Despite this risk reduction, elderly and severely immunosuppressed patients may still be at an increased risk for severe disease leading to hospitalization despite 1 booster dose, and may benefit from an additional booster dose [21]. Conversely, unvaccinated patients did not need to be highly vulnerable to develop severe disease from COVID-19. We found that 17.1% of unvaccinated patients admitted due to COVID-19 were aged <50 years, compared to 7.2% of fully vaccinated and 4.7% of boosted patients.

Table 2. Baseline Comorbidities of Patients Admitted due to Coronavirus Disease 2019

Comorbidity	Unvaccinated (n = 351)	Fully Vaccinated (n = 209)	Boosted (n = 107)	*P* Value
BMI, kg/m^2, median (IQR)	29.7 (25.6–35.1)	28.2 (24.3–34.2)	27.9 (24.2–33.4)	.121
Former/current smoker	183 (52.1)	116 (55.5)	65 (60.7)	.455
Severe immunosuppression	18 (5.1)	36 (17.2)	30 (28)	**<.001**
Solid organ transplant recipient	7 (2)	12 (5.7)	5 (4.7)	
Autoimmune disease on immunosuppressive therapy	5 (1.4)	7 (3.3)	4 (3.7)	
Hematologic malignancy with receipt of chemotherapy in past year	3 (0.9)	7 (3.3)	12 (11.2)	
Active cancer with receipt of chemotherapy in past year	3 (0.9)	9 (4.3)	8 (7.5)	
HSCT within the past year	0	1 (0.5)	0	
Other diagnosis on immunosuppressive therapy	0	0	1 (0.9)	
Cardiovascular disease	268 (76.4)	178 (85.2)	100 (93.5)	**<.001**
Diabetes mellitus	123 (35)	70 (33.5)	38 (35.5)	.913
Chronic lung disease	94 (26.8)	75 (35.9)	40 (37.4)	**.027**
Chronic kidney disease	47 (13.4)	46 (22)	27 (25.2)	**.004**
Cancer and/or hematologic malignancy without receipt of chemotherapy in past year	29 (8.3)	26 (12.4)	23 (21.5)	**<.001**
Dementia	17 (4.8)	19 (9.1)	12 (11.2)	**.037**
Chronic liver disease	12 (3.4)	11 (5.3)	7 (6.5)	.275
Autoimmune disease without active immunosuppressive therapy	10 (2.8)	10 (4.8)	9 (8.4)	**.047**
Pregnant	11 (3.1)	1 (0.5)	0	**.031**

Data are presented as No. (%) unless otherwise indicated. *P* values with bold font indicate statistical significance.

Abbreviations: BMI, body mass index; HSCT, hematopoietic stem cell transplant; IQR, interquartile range.

Only 5.1% of unvaccinated patients were severely immunosuppressed, compared to 17.2% and 28% of fully vaccinated and boosted patients, respectively. Vaccination has also been shown to be safe and to reduce severe disease in pregnancy [22, 23]. Of the 12 pregnant patients admitted due to COVID-19 during the study time period, all but 1 were unvaccinated.

All 3 cohorts had similar hospital lengths of stay as well as rates of pulmonary symptoms and hypoxia, though unvaccinated patients required higher levels of care. Significantly more unvaccinated patients required >6 L/minute of supplemental oxygen via nasal cannula compared to vaccinated patients, and although not statistically significant, favored toward higher rates of ICU-level care. This is despite unvaccinated patients being significantly younger with fewer comorbidities and less severe immunosuppression. Unvaccinated patients constituted 12 of the 13 cases aged <50 years requiring ICU-level care, and all 4 deaths that occurred in patients aged <50 years were among unvaccinated patients. Although mortality rates were similar among hospitalized patients regardless of vaccination status, the age-adjusted VE against mortality related to COVID-19 was estimated to be 84.7% and 94.8% for full vaccination and boosted status, respectively. We estimate it was 3.6 times less likely for a fully vaccinated person and 7.8 times less likely for a boosted person in the general population from our

Table 3. Clinical Course of Patients Admitted due to Coronavirus Disease 2019

Clinical Course	Unvaccinated (n = 351)	Fully Vaccinated (n = 209)	Boosted (n = 107)	*P* Value
Presence of pulmonary symptoms	291 (82.9)	177 (84.7)	83 (77.6)	.281
Required≤6 L/minute supplemental oxygen via nasal cannula	231 (65.8)	158 (75.6)	80 (74.8)	**.027**
Room air/no supplemental oxygen	93 (26.5)	52 (24.9)	31 (29)	
1–2 L/minute via nasal cannula (or 1–2 L/minute above baseline)	72 (20.5)	36 (17.2)	19 (17.8)	
3–6 L/minute via nasal cannula (or 3–6 L/minute above baseline)	66 (18.9)	70 (33.5)	30 (28)	
Required >6 L/minute supplemental oxygen via nasal cannula	120 (34.2)	51 (24.4)	27 (25.2)	**.027**
High-flow nasal cannula or noninvasive positive pressure ventilation	78 (22.3)	33 (15.8)	16 (15)	
Mechanical ventilation	42 (12)	18 (8.6)	11 (10.3)	
Required ICU-level care	93 (26.5)	39 (18.7)	21 (19.6)	.069
Length of stay (all patients), d, median (IQR)	4.2 (1.9–9)	3.6 (1.8–7)	4 (2.1–7.7)	.358
Length of stay (survivors), d, median (IQR)	3.8 (1.8–7.9)	3.2 (1.8–6.4)	4 (2.1–7.4)	.353
Mortality, any cause	48 (13.7)	27 (12.9)	12 (11.2)	.802
Mortality, due to COVID-19	43 (12.3)	22 (10.5)	11 (10.3)	.762

Data are presented as No. (%) unless otherwise indicated. *P* values with bold font indicate statistical significance.

Abbreviations: COVID-19, coronavirus disease 2019; ICU, intensive care unit; IQR, interquartile range.

Table 4. Estimated Vaccine Effectiveness Against Hospitalization, Need for Intensive Care, Mechanical Ventilation, All-Cause Mortality, and Coronavirus Disease 2019 (COVID-19)–Related Mortality Among Patients Admitted due to COVID-19

Age, y	Vaccination Status	VE Against Hospitalization, %	VE Against ICU-Level Care, %	VE Against IMV, %	VE Against All-Cause Mortality, %	VE Against COVID-19–Related Mortality, %
≥80	Primary series	76.8	83.3	82.8	83.1	86
	Boosted	91.3	96.5	97.7	94.1	93.7
70–79	Primary series	87.3	87.7	91.5	89.1	91.8
	Boosted	97.5	99	98.7	98.9	99.5
60–69	Primary series	76.6	85.6	68.8	53.2	50
	Boosted	93.8	93.3	89.1	91.3	89.5
50–59	Primary series	69.4	89.4	90.9	89.4	87.3
	Boosted	91	85.3	83.3	90.2	88.3
40–49	Primary series	78	100	100	100	100
	Boosted	88.6	83	65.9	100	100
30–39	Primary series	87.4	NA	NA	NA	NA
	Boosted	95.2	NA	NA	NA	NA
≤29	Primary series	91.9	100	100	100	100
	Boosted	100	100	100	100	100
All (age-adjusted)	Primary series	81.2	91.9	89.1	85.2	84.7
	Boosted	94.1	92.2	88	95.5	94.8

Abbreviations: COVID-19, coronavirus disease 2019; ICU, intensive care unit; IMV, invasive mechanical ventilation; NA, not applicable; VE, vaccine effectiveness.

region to die from COVID-19 during this study period compared to an unvaccinated person.

There are several important limitations to our study. Despite collecting data from 9 diverse hospitals, they are all located in western Pennsylvania, which may limit generalizability to other regions. Our health system does not routinely test for SARS-CoV-2 on every admission, which may result in a higher proportion of hospitalizations estimated to be due to COVID-19 when compared to other systems that do universal testing. It is also possible that clinicians may be biased to test unvaccinated patients more than vaccinated patients, which could have impacted our results. While manual records review introduces some level of subjectivity as to whether an admission is related to COVID-19, we believe the additional information available with this method makes it more accurate compared to reliance on electronic data extraction and billing diagnosis codes. Reliance on the EHR to determine vaccination status can also be inaccurate [24]. By manually reviewing all records, we were able to identify patients who were vaccinated but did not have their records updated in the EHR and would have thus been considered unvaccinated. Despite this method, there were still 87 admissions that had incomplete vaccination statuses and were excluded. As our center did not perform sequencing on patient samples to confirm infection with the Omicron variant, we selected 15 January 2022 as the start of our data collection since the preceding 2 weeks saw the Omicron variant constitute nearly all cases in the US, thus limiting the possibility of capturing a patient infected with the Delta variant [11]. Also, there were 2 patients who were considered boosted and were admitted to the hospital within 7 days of their booster dose. It is unlikely that they had a complete immunologic effect of a booster dose. Last, our analysis did not account for outpatient or inpatient therapeutics. As a result, it is unclear what impact therapeutics may have had on patient clinical courses based on vaccination status.

CONCLUSIONS

In this study, we report the clinical findings of hospitalizations during the Omicron variant BA.1 sublineage wave based on vaccination status. We found that unvaccinated patients diagnosed with COVID-19 were significantly more likely to be admitted specifically due to COVID-19 compared to fully vaccinated patients with or without a booster dose. Unvaccinated patients were younger, with fewer comorbidities and less severe immunosuppression, but required more intensive oxygen supplementation and, although not statistically significant, favored toward higher rates of ICU-level care. The age-adjusted VE against hospitalization from COVID-19 for the entire cohort was estimated to be 81.1% and 94.1% for full vaccination and boosted status, respectively, whereas VE against mortality related to COVID-19 was estimated to be 84.7% and 94.8%, respectively. Vaccination with a booster provides the greatest protection against hospitalization and death from COVID-19.

Notes

Patient consent. Our study does not include factors necessitating patient consent. Exempt status was granted by the Allegheny Health Network Institutional Review Board.

Potential conflicts of interest. T. L. W. has received consulting fees from Accelerate Diagnostics. D. R. C. is a member of the speaker's bureau for Merck. All other authors report no potential conflicts.

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.

References

1. Yu J, Collier AY, Rowe M, et al. Neutralization of the SARS-CoV-2 Omicron BA.1 and BA.2 variants. N Engl J Med **2022**; 386:1579–80.
2. Andrews N, Stowe J, Kirsebom F, et al. Covid-19 vaccine effectiveness against the Omicron (B.1.1.529) variant. N Engl J Med **2022**; 386:1532–46.
3. Tseng HF, Ackerson BK, Luo Y, et al. Effectiveness of mRNA-1273 against SARS-CoV-2 Omicron and Delta variants. Nat Med **2022**; 28:1063–71.
4. Sharma A, Oda G, Holodniy M. Effectiveness of mRNA-based vaccines during the emergence of SARS-CoV-2 Omicron variant [published online ahead of print 27 April 2022]. Clin Infect Dis **2022**. doi:10.1093/cid/ciac325
5. Ferdinands JM, Rao S, Dixon BE, et al. Waning 2-dose and 3-dose effectiveness of mRNA vaccines against COVID-19–associated emergency department and urgent care encounters and hospitalizations among adults during periods of Delta and Omicron variant predominance—VISION Network, 10 states, August 2021–January 2022. MMWR Morb Mortal Wkly Rep **2022**; 71:255–63.
6. Lauring AS, Tenforde MW, Chappell JD, et al. Clinical severity of, and effectiveness of mRNA vaccines against, covid-19 from Omicron, Delta, and Alpha SARS-CoV-2 variants in the United States: prospective observational study. BMJ **2022**; 376:e069761.
7. Abu-Raddad LJ, Chemaitelly H, Ayoub HH, et al. Effect of mRNA vaccine boosters against SARS-CoV-2 Omicron infection in Qatar. N Engl J Med **2022**; 386: 1804–16.
8. Tenforde MW, Self WH, Gaglani M, et al. Effectiveness of mRNA vaccination in preventing COVID-19-associated invasive mechanical ventilation and death—United States, March 2021–January 2022. MMWR Morb Mortal Wkly Rep **2022**; 71:459–65.
9. Iuliano AD, Brunkard JM, Boehmer TK, et al. Trends in disease severity and health care utilization during the early Omicron variant period compared with previous SARS-CoV-2 high transmission periods—United States, December 2020–January 2022. MMWR Morb Mortal Wkly Rep **2022**; 71:146–52.
10. Paredes MI, Lunn SM, Famulare M, et al. Associations between SARS-CoV-2 variants and risk of COVID-19 hospitalization among confirmed cases in Washington State: a retrospective cohort study [manuscript published online ahead of print 12 April 2022]. Clin Infect Dis **2022**. doi:10.1093/cid/ciac279.
11. Centers for Disease Control and Prevention. COVID data tracker. https://covid.cdc.gov/covid-data-tracker. Accessed 11 May 2022.
12. Modes ME, Directo MP, Melgar M, et al. Clinical characteristics and outcomes among adults hospitalized with laboratory-confirmed SARS-CoV-2 infection during periods of B.1.617.2 (Delta) and B.1.1.529 (Omicron) variant predominance—One Hospital, California, July 15–September 23, 2021, and December 21, 2021–January 27, 2022. MMWR Morb Mortal Wkly Rep **2022**; 71:217–23.
13. Zweig D. Our most reliable pandemic number is losing meaning. **2021**. https://www.theatlantic.com/health/archive/2021/09/covid-hospitalization-numbers-can-be-misleading/620062/. Accessed 16 May 2022.
14. Carbajal E. Hospitals see more patients 'with COVID-19' vs. 'for COVID-19.' **2022**. https://www.beckershospitalreview.com/patient-safety-outcomes/hospitals-see-more-patients-with-covid-19-vs-for-covid-19.html. Accessed 23 May 2022.
15. Moffa MA, Shively NR, Walsh TL. Characteristics of postvaccination coronavirus disease 2019 hospitalizations prior to booster vaccines. Open Forum Infect Dis **2022**; 9:ofac014.
16. Pennsylvania Department of Health. COVID-19 vaccine dashboard. https://www.health.pa.gov/topics/disease/coronavirus/Vaccine/Pages/Dashboard.aspx. Accessed 15 February 2022.
17. Allegheny County Health Department. COVID-19 dashboard. https://www.alleghenycounty.us/Health-Department/Resources/COVID-19/COVID-19-Dashboards.aspx. Accessed 18 March 2022.
18. Centers for Disease Control and Prevention. Stay up to date with your COVID-19 vaccines. **2022**. https://www.cdc.gov/coronavirus/2019-ncov/vaccines/stay-up-to-date.html. Accessed 2 April 2022.
19. Klann JG, Strasser ZH, Hutch MR, et al. Distinguishing admissions specifically for COVID-19 from incidental SARS-CoV-2 admissions: a national retrospective EHR study. J Med Internet Res **2022**; 24:e37931.
20. Antonelli M, Penfold RS, Merino J, et al. Risk factors and disease profile of post-vaccination SARS-CoV-2 infection in UK users of the COVID Symptom Study app: a prospective, community-based, nested, case-control study. Lancet Infect Dis **2022**; 22:43–55.
21. Arbel R, Sergienko R, Friger M, et al. Effectiveness of a second BNT162b2 booster vaccine against hospitalization and death from COVID-19 in adults aged over 60 years. Nat Med **2022**; 28:1486–90.
22. Prasad S, Kalafat E, Blakeway H, et al. Systematic review and meta-analysis of the effectiveness and perinatal outcomes of COVID-19 vaccination in pregnancy. Nat Commun **2022**; 13:2414.
23. Stock SJ, Carruthers J, Calvert C, et al. SARS-CoV-2 infection and COVID-19 vaccination rates in pregnant women in Scotland. Nat Med **2022**; 28:504–12.
24. Greene SK, Shi P, Dutta-Linn MM, et al. Accuracy of data on influenza vaccination status at four Vaccine Safety Datalink sites. Am J Prev Med **2009**; 37:552–5.