Observational Study

Medicine

OPEN

Comparing demographics, clinical characteristics, and hospital outcomes by vaccine uptake status

A single-institution cross-sectional study

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Abstract

Vaccination against Coronavirus disease 2019 (COVID-19) has been the cornerstone of reducing morbidity and mortality of this disease, as it has been shown to decrease the risk of viral transmission, severity of disease, hospitalization, and intubation. However, true understanding of its impact is skewed by heterogeneous vaccine administration due to lack of equitable access, vaccine hesitancy, and varying social determinants of health. Therefore, this study aims to identify groups that are less likely to be vaccinated and understand whether the resultant differences in vaccination rates affect morbidity and mortality in socially marginalized COVID-19 patients. A retrospective cohort analysis was performed on a randomized and stratified population of 939 COVID-19 patients from January 2021 to December 2021. Bivariate analysis and logistic regression were used to assess demographic and clinical characteristic trends in unvaccinated, partially vaccinated, and fully vaccinated groups. No one age (P = .21), gender (P = .9), race (P = .12), ethnicity (P = .09), or health insurance status (P = .13) group was more vaccinated than the other. Similarly, no subgroup was at increased odds of intubation (P = .08) or death. However, patients with all categories of comorbidities including cardiopulmonary disease (P = <.001, effect size .17), renal disease (P = <.001, effect size 0.138), metabolic disease (P = .04), and immunocompromised (P = .01) states were found to have significantly higher vaccination rates. Our study also shows that full vaccination protects against mortality and decreases the odds of intubation by 55% (adjusted odds ratio = 0.453, P value = .015) compared to no vaccination or partial vaccination. Findings from this study show an encouraging trend that sicker patients had higher rates of vaccination against COVID-19. This trend highlights the need for further identification of motivators that may be applied to vaccine-hesitant populations, which can help guide population-level policy, increase vaccination campaign yield, and reach for health equity.

Abbreviations: COVID-19 = coronavirus disease 2019, ICU = intensive care unit, IRB = institutional review board, LOS = length of stay, US = United States.

Keywords: comorbidity, COVID-19, risk factors for intubation, vaccine acceptance, vaccine confidence, vaccine hesitancy, vaccine uptake

1. Introduction

As of early 2023, the Coronavirus disease 2019 (COVID-19) has led to the loss of over 1 million American lives.[1] With the release of the primary COVID-19 vaccine series in December 2020, an estimated 20 million lives have been saved in the first year of vaccination on a global scale.[2] When including the effects of the univalent[3] and bivalent[4] boosters released in 2021 and 2022, respectively, an estimated 3.2 million lives in the United States (US) have been saved. The vaccine has been shown to decrease the risk of viral transmission,[5] hospitalization, intubation,[6] and overall severity of infection.[7] Even in the face of waning immunity and potentially resultant breakthrough infections, vaccinated patients have lower

Waiver of informed consent was obtained due to the retrospective nature of this paper.

The authors have no funding and conflicts of interest to disclose.

The datasets generated during and/or analyzed during the current study are available from the corresponding author on reasonable request.

The study was conducted according to the guidelines of the Declaration of Helsinki and approved by the Institutional Review Board of the University of Nevada, Las Vegas (IRB #UNLV-2022–244) and University Medical Center of Southern Nevada, Las Vegas (IRB #UMC-2022–416).

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How to cite this article: Chen CX, Cabugao P, Nguyen M, Villegas D, Batra K, Singh A, Kioka M. Comparing demographics, clinical characteristics, and hospital outcomes by vaccine uptake status: A single-institution cross-sectional study. Medicine 2023;102:40(e35421).

Received: 7 July 2023 / Received in final form: 5 September 2023 / Accepted: 6 September 2023

http://dx.doi.org/10.1097/MD.0000000000035421

hospitalization rates,[8] risk of progression to severe infection,[9] and in-hospital mortality.[10] Despite the evidence related to these benefits of the COVID-19 vaccines, true understanding of its impact is skewed by heterogeneous vaccine administration due to lack of equitable access, vaccine hesitancy, and varying social determinants of health.[11,12]

These social determinants of health can act at the individual and systemic level, which leads to disparities such as vaccine inequities. At an individual level, vaccine hesitancy has been associated with socio-demographic characteristics, such as belonging to a minority race or ethnicity, residency in rural areas, education status of a high-school diploma or less, limited health literacy, and poor vaccine confidence.[12] Low education status (e.g., high school diploma or less) has been identified as a strong predictor of believing in conspiracy theories.[13] Reportedly, a study in the US revealed that nearly 55% of their participants believed that previous vaccines given for measles and mumps caused autism, and nearly 1/4th of the sample perceived that the COVID-19 vaccine could lead to alterations in the genetic material of an individual.[14] At a systemic level, vaccine availability and accessibility vary by regional economic standing. For instance, high-income regions tend to obtain higher quantities of vaccines; however, this does not translate into higher vaccine uptake due to several individual-related attributes (e.g., belonging to a minority race or ethnicity, vaccine hesitancy). This points to the interconnectivity between individual and systemic level factors.[2]

In the US, African American, Latinx, and Native American populations have lower vaccination rates and higher mortality rates when compared to Caucasian communities despite comprising a smaller percentage of the national population.[11] This is possibly due to higher rates of medical distrust, lack of insurance, and likelihood of being employed as a frontline worker, as well as an increased rate of comorbidities that can significantly increase risk of morbidity and mortality.[11] For instance, hypertension has been linked to a 4-fold increase in severe COVID-19 infection and a 6-fold increase in death[7]; obesity (body mass index >30) has been found to triple the risk of intubation and nearly double the risk of death[7]; and type 2 diabetes mellitus has been associated with an increased risk of severe infection, hospitalization and intensive care unit (ICU) level of care.[15] Additionally, patients with multiple comorbidities have been found to have decreased antibody titer levels[16] and overall vaccine efficacy.[17] The current death toll is a direct consequence of the COVID-19 pandemic compounding with preexisting epidemics, as 45% of the US population has a diagnosis of hypertension, 42% is obese, and 15% are diabetic,[18] all of which affect minorities at higher rates than Caucasian patients.[18–20]

Therefore, it is important to understand vaccine uptake patterns in patients with varying demographics and comorbidities in order to analyze their clinical implications. In this backdrop, this study aims to compare demographic, clinical, and hospitalization outcomes by vaccination status in an urban tertiary-level hospital setting. Our secondary objective investigates the rate of vaccine uptake among patients with preexisting disorders. Additionally, we sought to examine predictors of intubation after controlling for socio-demographic, clinical, and vaccine uptake status.

2. Methods

2.1. Study design, setting, and sampling

This retrospective, single institutional, cross-sectional study utilized patients electronic medical records from January 1, 2021 to December 31, 2021 in an urban-based tertiary care teaching hospital in Nevada.

Patient demographics including age, gender, race, ethnicity, and smoking status were obtained via manual chart review. Vaccination status was also obtained via the Nevada statewide immunization registry (webiz.nv.gov), which was automatically updated daily. Vaccination status was defined as unvaccinated (i.e., no vaccinations), partial (e.g., 1/2 Pfizer or Moderna vaccinations), full (e.g., 2/2 Pfizer or Moderna vaccinations, 1/1 Janssen vaccinations), or boosted (i.e., additional vaccinations beyond full vaccination).

Proxies for severity of hospitalization course including ICU upgrade, ICU days, intubation status, peak mode of oxygen delivery (e.g., nasal cannula, ventilator), peak oxygen delivered, and overall length of hospital stay were extracted via manual chart review. Disposition locations were tallied and categorized as either discharge to home or self-care, healthcare facility (e.g., rehabilitation centers, long-term acute care facilities), other (i.e., behavioral, custodial care, law enforcement, or left against medical advice), or expiration. Comorbidities were categorized as cardiopulmonary, metabolic, renal, or immunocompromised status.

2.2. Study population

Medical records of patients aged at least 18 years with a confirmed diagnosis of COVID-19 via nasal or oropharyngeal swab reverse transcription polymerase chain reaction testing were included in this study. To increase sample representation, 994 patients were selected from a pool of a total of 2186 via stratified, random sampling. Stratification approximated the national census distribution across population parameters in terms of gender, race, and ethnicity as such: 48% male, 52% female; 75% White, 13% African American, 6% Asian or Pacific Islander, 6% American Indian or Alaska Native or other; 18% Hispanic and 82% non-Hispanic, respectively. Stratified sampling was performed via Excel RAND function. Figure 1 details the selection process.

2.3. Ethical considerations

The institutional review board (IRB) of the University of Nevada, Las Vegas (IRB #UNLV-2022–244) and University Medical Center of Southern Nevada, Las Vegas (IRB #UMC-2022–416) granted this study a waiver of informed consent as given the large sample size and significant mortality rate stemming from the COVID-19 pandemic, informed consent was neither practical nor applicable.

2.4. Quality control and data privacy

A coded identifier list was created in Excel to protect the privacy of all study participants by segregating medical record numbers from deidentified data points. Two password-protected spreadsheets were made with patient medical records attached to a unique subject code and each unique subject code with associated biometric identifiers. Vaccination status was obtained from retrospective chart review as documented by healthcare providers on admission in accordance with institutional infectious disease protocol.

2.5. Data analyses

Data was first cleaned and re-coded for running analytical operations. Categorical variables were represented as frequencies and proportions, whereas continuous variables were represented by mean and standard deviations. The Chi-square test was used for comparing the categorical groups. Adjusted standardized residuals >2 were considered significant cells for contingency tables larger than 2×2. Continuous outcomes among 3 groups (unvaccinated, partially vaccinated, and fully vaccinated) were compared using one-way analysis of variance. A logistic regression model was fit to generate adjusted odds ratios for the likelihood of intubation as an outcome. For regression

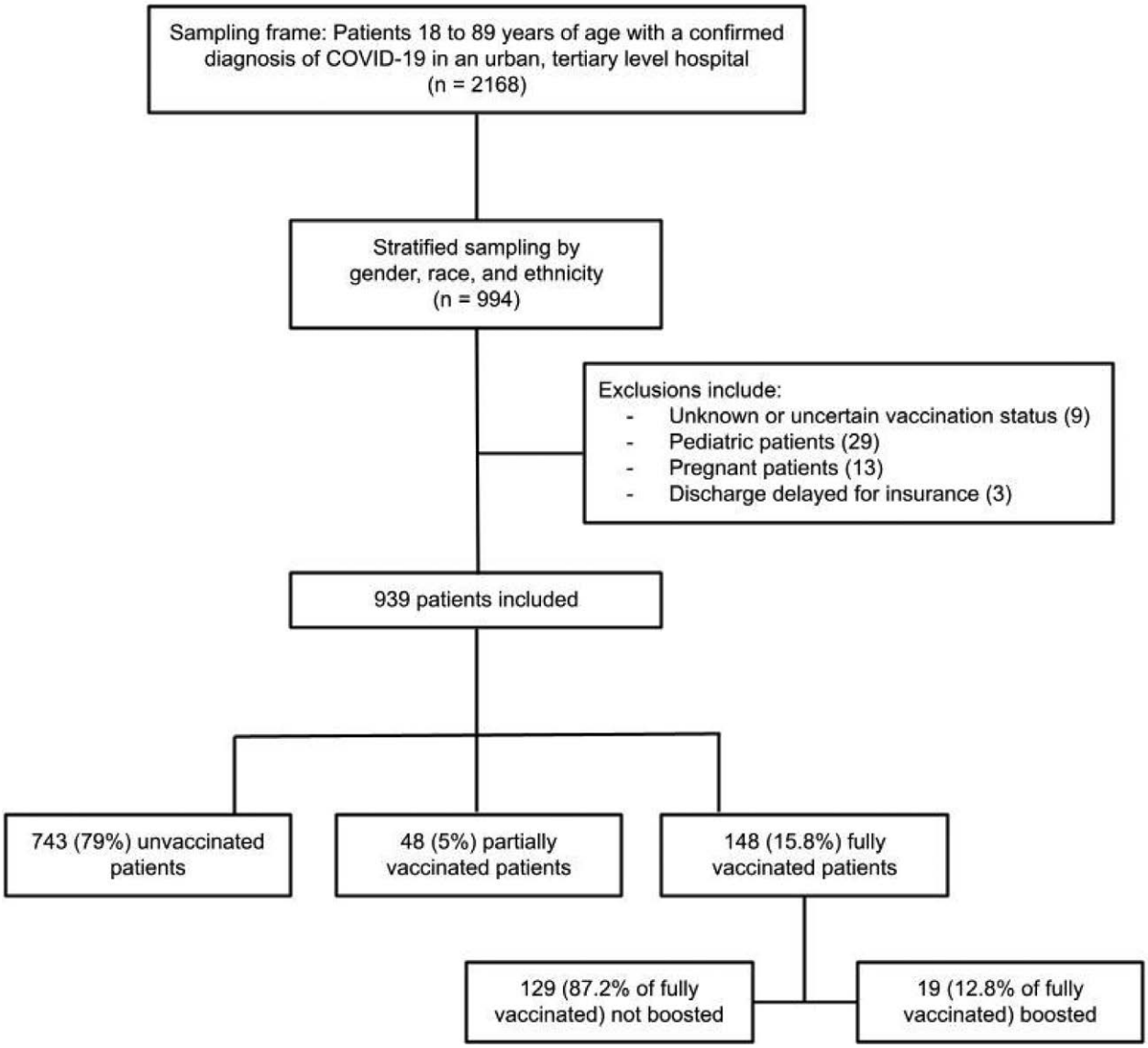

Figure 1. Sample selection flow diagram. COVID-19 = coronavirus disease of 2019.

analyses, polytomous categorical variables were dummy coded to calculate accurate parameters. For assessing the fits of the regression model, we used Hosmer and Lemeshow test (Hosmer & Lemeshow, 2013). All tests were 2-sided, and a *P* value of < .05 was considered significant. The Statistical Package for Social Sciences for Windows, version 27.0 (Statistical Package for social science, Chicago, IL).[21]

3. Results

A total of 939 patients were included in the study (Table 1), of which male participants summed a total of 456 (48.6%) and females a total of 483 (51.4%). Our study predominantly included White participants (n = 702, 74.8%) compared to Black (n = 123, 13.1%), Asian (n = 58, 6.2%), or other races (n = 56, 6%). Smoking status was categorized based on current tobacco use (n = 129, 13.7%), non-user (n = 587, 62.5%), and history of tobacco use (n = 213, 22.9%). Of the 939 patients in our study, there were 743 (79.1%) unvaccinated patients, 48 (5.1%) partially vaccinated patients, and 148 (15.8%) fully vaccinated patients. Of the patients that were fully vaccinated, a total of 19 (12.8%) patients had obtained booster vaccination (i.e., a third dose) while the other 129 (87.2%) patients did not receive booster vaccinations. The vaccine brands that were identified in this study among the patients that were either partially or fully vaccinated (n = 296) include Pfizer (60.7%), Moderna (29.6%), and Janssen (9.7%).

Table 2 demonstrates clinical characteristics of the 939 patients. A total of 616 (65.6%) were discharged home, 97 (10.3%) were discharged to a healthcare facility (e.g., rehabilitation centers, long-term acute care facilities), 167 (17.8%) expired, and 59 (6.3%) were discharged to other facilities (i.e., behavioral facilities, custodial care, law enforcement, or left against medical advice). 921 (98.1%) patients were hospitalized, of which 239 (25.5%) required upgrade to the ICU. Length of stay (LOS) on average was 11.23 (standard deviation = ±17.321) days, and the average length of ICU stay was 11.79 (standard deviation = ±13.383) days. In total, 131 (14%) patients were intubated. 86 (9.2%) patients had comorbidities associated with immunocompromisation (refer to section 2.1. for a list of included comorbidities). 152 (16.3%) patients had renal disease; 487 (52%) patients had cardiopulmonary disease; and 478 (51.1%) patients had metabolic disease.

Analysis of Table 3 showed that there were no significant differences by demographic characteristics, such as age, gender, race, ethnicity, or insurance status. Table 3 also illustrates that

Table 1

Demographic characteristics of the sample (N = 939).

Variables	Categories	Number (%)	95% CIs
Age (Mean ± SD)		56.69 ± 16.980	(55.60–57.78)
Gender	Male	456 (48.6)	(45.4–51.8)
	Female	483 (51.4)	(48.2–54.6)
Race	White	702 (74.8)	(71.9–77.5)
	Black	123 (13.1)	(10.9–15.3)
	Asian	58 (6.2)	(4.6–7.7)
	Other	56 (6.0)	(4.5–7.9)
Ethnicity	Hispanic	314 (33.6)	(30.4–36.5)
	Non-Hispanic	620 (66.4)	(63.0–69.1)
Health insurance	Public	625 (66.6)	(63.5–69.6)
	Private	227 (24.2)	(21.4–26.9)
	Self-insured	77 (8.2)	(6.5–9.9)
	Other	10 (1.1)	(0.4–1.7)
Smoking status	Current smoker	129 (13.7)	(11.5–15.9)
	Nonsmoker	587 (62.5)	(59.4–65.6)
	Former smoker	213 (22.9)	(20.0–25.4)
Vaccination status	Unvaccinated	743 (79.1)	(76.5–81.7)
	Partially vaccinated	48 (5.1)	(3.7–6.5)
	Fully vaccinated	148 (15.8)	(13.4–18.1)
Boosted among full vaccinated (n = 148)	Yes	19 (12.8)	(7.5–18.2)
	No	129 (87.2)	(81.8–92.5)
Vaccine brand among partially or fully vaccinated subjects (n = 296)	Pfizer	119 (60.7)	(53.8–67.5)
	Moderna	58 (29.6)	(23.2–35.9)
	Janssen	19 (9.7)	(5.5–13.8)

Data are represented as frequencies and proportions unless stated otherwise. The percentage may not add up to 100% due to a small amount of missing data.
CI = confidence interval, SD = standard deviation.

Table 2

Clinical characteristics of the sample (N = 939).

Variable	Categories	Number (%)	95% CIs
Hospital disposition	Home or selfcare	616 (65.6)	(62.5–68.6)
	Healthcare facility	97 (10.3)	(8.5–12.5)
	Expired	167 (17.8)	(15.4–20.4)
	Other	59 (6.3)	(4.8–8.0)
In-patient hospitalization	Yes	921 (98.1)	(96.9–98.7)
	No	18 (1.9)	(1.1–3.0)
ICU stay	Yes	239 (25.5)	(22.7–28.4)
	No	700 (74.5)	(71.6–77.3)
LOS (M ± SD)		11.23 ± 17.32	(10.12–12.34)
ICU stay (M ± SD)		11.79 ± 13.38	(10.09–13.50)
Intubation status	Yes	131 (14.0)	(11.8–16.3)
	No	808 (86.0)	(83.7–88.2)
Peak oxygen requirement (M ± SD)		22.42 ± 28.31	(20.40–24.45)
Immunocompromised status	Yes	86 (9.2)	(7.4–11.1)
	No	846 (90.8)	(88.0–91.9)
Renal disease	Yes	152 (16.3)	(13.9–18.7)
	No	781 (83.7)	(80.6–85.5)
Cardiopulmonary disease	Yes	487 (52.0)	(48.6–55.1)
	No	450 (48.0)	(44.7–51.2)
Metabolic disease	Yes	478 (51.1)	(47.6–54.2)
	No	458 (48.9)	(45.6–51.9)

Data are represented as frequencies and proportions unless stated otherwise. The percentage may not add up to 100% due to small amounts of data.
CI = confidence interval, ICU = intensive care unit, LOS = length of stay, M = mean, SD = standard deviation.

there were no significant differences between the 3 groups concerning hospital admission (P value = .38), overall LOS (P value = .88), ICU requirement (P value = .44), ICU days (P value = .61), intubation status (P value = .08), and peak oxygen requirement (P value = .20). However, our study shows that a significantly higher proportion of unvaccinated patients expired as opposed to those being fully vaccinated patients (19.9% vs 8.8%, P value = .02). In our cohort of fully vaccinated people, a significantly larger proportion of patients had immunocompromised conditions (15.6% vs 10.6%, P = .01), renal diseases (27.9% vs 10.4%, P < .001), cardiopulmonary conditions (71.4 vs 54.2%, P < .001), and metabolic disturbances (59.5% vs 57.4%, P = .04) as opposed to those who were partially vaccinated.

Table 4 shows that odds of intubation were compared across multiple demographics, but no one age (P = .072), gender (P = .207), race, ethnicity, or insurance group was more or less likely to be intubated. When compared to non-Hispanic Black patients, Whites (P = .289), Asians (P = .312), and other races (P = .167) did not have increased odds of intubation. Similarly, when compared to non-Hispanic patients, Hispanics did not have a statistically significant increased risk of intubation (P = .257). No significant difference was noted across public, (P = .05), private (P = .921), or other insurances (P = .813) when compared to self-insured populations. Patients with all comorbidity classes including cardiopulmonary (P = .784), renal (P = .921), immunocompromisation (P = .805), and metabolic (P = .402) diseases were not at increased odds of intubation. However, fully vaccinated patients were found to have 55% less odds of being intubated (adjusted odds ratio = 0.453, P = .015) compared to unvaccinated persons. In contrast, partially vaccinated patients were not found to have comparatively less odds of intubation (P = .402).

4. Discussion

Our study found that fully vaccinated patients have better clinical outcomes including decreased mortality rates and odds of being intubated. However, we did not find any socio-demographic characteristics to be associated with intubation. Full vaccination status had the greatest predictive influence over other variables of interest, which underscores the need to develop or reinforce primary vaccine series completion rates. This study contributes to the growing evidence that full vaccination against COVID-19 decreases mortality and morbidity, as previously seen in studies conducted in both wealthy (e.g., Israel)[6] and developing (e.g., South Africa)[22] regions despite their varying demographic distributions, socioeconomic makeup, or healthcare systems. Intubation risk factors remain controversial as some studies have identified males, smokers, the elderly, African Americans, and diabetics as higher risk for intubation, longer hospital LOS, number of comorbidities, and mortality,[23–25] while others report no associated risk with any race, ethnicity or insurance type.[25] In regards to health status, our study reported that people with preexisting conditions had a significantly higher proportion of vaccine uptake and completion rates.

It is encouraging that patients with comorbidities were more often fully vaccinated, as they are prone to increased rates of morbidity and mortality.[2] Government-mandated vaccination prioritization for certain vulnerable groups (i.e., elderly, healthcare workers), and comorbid patients during early vaccine roll-out campaigns may have partly contributed to these results. Also, multiple studies have noted that sicker patients and those who are immunocompromised tend to be more vaccinated.[26–28] Reviews of databases from a large US-based insurance group noted that immunocompromised patients were more likely to have completed a primary COVID-19 vaccine series if they were elderly or on aggressive immunosuppressive pharmaceuticals (e.g., chemotherapy) compared to those with milder immunosuppression (e.g., oral prednisone).[26] This trend continues across different comorbidity categories. Hemodialysis-dependent patients have been found to have lower vaccine hesitancy compared to the general population, despite receiving

Table 3

Bivariate comparisons of demographic and clinical characteristics of the sample (N = 939).

Variable	Categories	Unvaccinated	Partially vaccinated	Fully vaccinated
Age (M ± SD)		56.21 ± 16.98	57.27 ± 15.55	58.91 ± 17.36
Gender	Male	360 (48.5)	24 (50.0)	72 (48.6)
	Female	383 (51.5)	24 (50.0)	76 (51.4)
Race	White	564 (75.9)	34 (70.8)	104 (70.3)
	Black	94 (12.7)	6 (12.5)	23 (15.5)
	Asian	39 (5.2)	7 (14.6)	12 (8.1)
	Other	46 (6.2)	1 (2.1)	9 (6.1)
Ethnicity	Hispanic	259 (35.0)	10 (20.8)	45 (30.6)
	Non-Hispanic	280 (65.0)	38 (79.2)	102 (69.4)
Health insurance	Public	492 (66.2)	27 (56.3)	106 (71.6)
	Private	175 (23.6)	18 (37.4)	34 (23.0)
	Self-insured	66 (8.9)	3 (6.3)	8 (5.4)
	Other	10 (1.3)	0 (0.0)	0 (0.0)
Hospital disposition	Home or selfcare	481 (64.7)	30 (62.5)	105 (70.9)
	Healthcare facility	69 (9.3)	7 (14.6)	21 (14.2)
	Expired	148* (19.9)	6 (12.5)	13* (8.8)
	Other	45 (6.1)	5 (10.4)	9 (6.1)
Hospital admission	Yes	730 (98.3)	47 (97.9)	144 (97.3)
	No	13 (1.7)	1 (2.1)	4 (2.7)
ICU upgrade	Yes	196 (26.4)	10 (20.8)	33 (22.3)
	No	547 (73.6)	38 (79.2)	115 (77.7)
Overall LOS (M ± SD)		11.36 ± 16.042	10.15 ± 10.33	10.97 ± 24.10
ICU d (M ± SD)		11.91 ± 13.56	14.80 ± 7.58	10.18 ± 13.76
Intubation status	Yes	111 (14.9)	8 (16.7)	12 (8.1)
	No	632 (85.1)	40 (83.3)	136 (91.9)
Peak oxygen requirement (M ± SD)		23.05 ± 28.36	25.10 ± 27.86	18.15 ± 28.03
Immunocompromised status	Yes	58* (7.9)	5 (10.6)	23* (15.6)
	No	680 (92.1)	42 (89.4)	124 (84.4)
Renal disease	Yes	106* (14.4)	5 (10.4)	41* (27.9)
	No	632 (85.6)	43 (89.6)	106 (72.1)
Cardiopulmonary disease	Yes	356* (48.0)	26 (54.2)	105* (71.4)
	No	386 (52.0)	22 (45.8)	42 (28.6)
Metabolic disease	Yes	363* (49.0)	27 (57.4)	88* (59.5)
	No	378 (51.0)	20 (42.6)	60 (40.5)

Data are represented as frequencies and proportions unless stated otherwise.

Categories marked with an asterisk are statistically significant and had adjusted residual values >2 as described in the methods.

ICU = intensive care unit, LOS = length of stay, M = mean, SD = standard deviation.

Table 4

Predictors of intubation (N = 939).

Variables	OR (95% CIs)	*P* value
Age	1.011 (1.00–1.02)	.072
Gender (Ref: Female)	1.283 (0.87–1.89)	.207
White vs Non-Hispanic Black	0.732 (0.41–1.30)	.289
Asian vs Non-Hispanic Black	0.61 (0.23–1.591)	.312
Other races vs Non-Hispanic Black	0.463 (0.16–1.38)	.167
Hispanic (Ref: Non-Hispanic)	1.291 (0.83–2.01)	.257
Public insurance vs self-insured	1.28 (0.60–2.72)	.52
Private insurance vs self-insured	0.959 (0.42–2.21)	.921
Other insurance vs self-insured	0.767 (0.085–6.93)	.813
Partially vaccinated vs unvaccinated	1.281 (0.57–2.87)	.547
Fully vaccinated vs unvaccinated	0.453 (0.24–0.86)	.015
Cardiopulmonary disease (Y/N)	1.062 (0.69–1.63)	.784
Renal disease (Y/N)	1.661 (1.01–2.74)	.05
Immunocompromised (Y/N)	1.086 (0.57–2.09)	.805
Metabolic disease (Y/N)	0.84 (0.56–1.26)	.402

The logistic regression model was determined by the Hosmer and Lemeshow test ($P = .953$). The model correctly classified 85.9% of cases. Of the 9 predictor variables, only one was statistically significant: fully vaccinated status (as shown in Table 4). Fully vaccinated individuals had 55% less odds to be intubated (adjusted odds ratio = 0.453, P value = .015, Table 4).

CIs = confidence intervals, OR = odds ratio.

the majority of their COVID-19 related information from television news.[27] Vaccination has also been found to be predictive of medical compliance. COVID-19 vaccinated kidney transplant patients have been found to have higher rates of postoperative adherence to follow-up appointments and therapeutic tacrolimus troughs.[28] Even in uninsured and socially marginalized communities, sicker patients have higher vaccination rates. A study on recreational drug users found that those with HIV, higher alcohol consumption, or more years of recreational drug injection were more likely to be vaccinated despite lower overall vaccination rates compared to the general public.[14] Additionally, this trend extends beyond just vaccination against COVID-19. Historically, patients with fewer comorbidities have had lower influenza vaccination rates.[29] Few studies have investigated the specific motivators behind higher rates of vaccination in patients with comorbidities. Potential contributors include higher access to healthcare for treatment of their preexisting illnesses; increased exposure to providers that may dispel misinformation gained from non-medical sources such as social media; prior experience with healthcare interventions; and overall increased concern for personal well-being.[26–29]

However, our study did not identify any demographic subgroup that was more or less vaccinated. This is in contrast with many US-based studies that have found higher rates of vaccination in the elderly,[7] Caucasian and Asian communities,[30–32] and regions with high insurance coverage.[33,34] Many studies have also found lower rates of immunization in African Americans, nonwhite Hispanics,[31,35] and patients with no insurance, housing instability, food insecurity, conservative political views, and education restricted to a high-school diploma or less.[33] This discrepancy may be attributed to different study designs and varying data collection methods. For example, the majority of studies were cross-sectional in nature that involved survey based research, which means participants were able to report their willingness for vaccination. In contrast, the current study utilized retrospective data collection using patient records, which gives us no ability to gauge the participants willingness. In our study, vaccine uptake could be considered as a surrogate for vaccine acceptability.

4.1. Future considerations

Future studies must explore the reasons behind increased vaccination rates in patients with comorbidities. Identification of specific motivators can influence public policy and ability to apply them to populations that are prone to lower vaccination rates. Public education campaigns can also utilize these motivators to overcome misinformation and other sources of conspiracy theories, particularly among those with lower education status who tend to have lower vaccination rates.[33] Future studies may also investigate the correlates of vaccine uptake in comorbid patients, which will help explore the intersection between social determinants of health and the health statuses of an individual. It would also be interesting to see urban-rural disparities in vaccine uptake to identify systemic factors influencing vaccination uptake.

4.2. Strengths and limitations

This study consists of a patient sample that mirrors the US census distribution in terms of gender, race, and ethnicity as closely as possible. However, this study is not without limitations. First, given the limited geographic scope of this single-institution study, our ability to generalize our findings to the overall nation would be difficult. In other words, external validity of this study will be limited. Second, since this study involves measurement of exposure and outcomes concurrently,

the temporal sequence between cause and effect cannot be determined. This highlights the importance of designing prospective or interventional studies. Third, given the inherent limitations of retrospective data collection in which patients were not directly involved, it is likely that partially vaccinated participants may have later become fully vaccinated, which does not necessarily mean that they were vaccine-hesitant but rather progressing towards full vaccination status. The association between vaccine uptake and acceptability is not quantified and requires further investigation. Next, there is a possibility of residual confounding bias in this study due to unmeasured variables, such as time elapsed from last vaccination (e.g., effects of waning immunity) or prior COVID-19 infection (e.g., effects of "natural immunity"), which might have provided the ability to investigate predictors of breakthrough infections. This sets a potential avenue for future research. Additionally, our study also does not account for patients who received heterogeneous combinations of vaccine brands (e.g., 1 dose of Pfizer and 1 dose of Moderna for a full primary series), as previous studies have noted that mix-and-and-match vaccine combinations have superior increases in antibody production when compared to homologous vaccine series administration.[36] Future studies of randomized control trials to assess heterologous versus homologous vaccine booster efficacy are needed.

5. Conclusions

Vaccination is currently our most effective weapon in fighting the COVID-19 pandemic, but is not uniformly available nor accepted in all populations. Our study did not identify any age, gender, ethnicity, or health insurance status group that was more vaccinated than the other. However, our study did find that full vaccination status protects against intubation and mortality. Identifying factors that can facilitate vaccine uptake can lead to decreased viral transmission, prevent hospitalizations, and ultimately save lives. Additionally, finding subgroups of comorbid patients with lower vaccination rates can guide population-level policy, increase vaccination campaign yield, and reach for health equity.

While this study did not identify any vulnerable groups that were less likely to be vaccinated, we did find that patients with comorbidities of all types were more likely to be vaccinated. Further exploration of motivations for vaccination in this population is useful for modeling in vaccine-hesitant populations at the population level, as well as reinforcing in chronically ill patients as they are at increased risk of blunted immune response to the vaccine and therefore severe illness. These motivators should also be investigated in the context of social determinants of health to protect the most vulnerable members of society.

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References

[1] Mathieu E, Ritchie H, Rodés-Guirao L, et al. 2020 Coronavirus pandemic (COVID-19). Available at: OurWorldInData.org [access date January 15, 2022].
[2] Watson OJ, Barnsley G, Toor J, et al. Global impact of the first year of COVID-19 vaccination: a mathematical modelling study. Lancet Infect Dis. 2022;22:1293–302.
[3] FDA authorizes a booster dose of Pfizer-BioNTech COVID-19 vaccine for certain populations. 2021 Available at: https://www.fda.gov/news-events/press-announcements/fda-authorizes-booster-dose-pfizer-biontech-covid-19-vaccine-certain-populations [access date January 15, 2022].
[4] Coronavirus (COVID-19) update: FDA authorizes moderna and Pfizer-BioNTech bivalent COVID-19 vaccines for use. 2021 Available at: https://www.fda.gov/news-events/press-announcements/coronavirus-covid-19-update-fda-authorizes-moderna-pfizer-biontech-bivalent-covid-19-vaccines-use [access date January 15, 2022].
[5] Prunas O, Warren JL, Crawford FW, et al. Vaccination with BNT162B2 reduces transmission of SARS-COV-2 to household contacts in Israel. Science. 2022;375:1151–4.
[6] Rinott E, Youngster I, Lewis YE. Reduction in COVID-19 patients requiring mechanical ventilation following implementation of a national COVID-19 vaccination program — Israel, December 2020–February 2021. MMWR Morb Mortal Wkly Rep. 2021;70:326–8.
[7] Nagy E, Cseh V, Barcs I, et al. The impact of comorbidities and obesity on the severity and outcome of COVID-19 in hospitalized patients-a retrospective study in a Hungarian Hospital. Int J Environ Res Public Health. 2023;20:1372.
[8] Tartof SY, Slezak JM, Fischer H, et al. Effectiveness of mRNA BNT162b2 COVID-19 vaccine up to 6 months in a large integrated health system in the USA: a retrospective cohort study. Lancet. 2021;398:1407–16.
[9] Hossain R, Jeudy J, White CS. Chest radiographic and CT findings in patients hospitalized with breakthrough COVID-19. Radiol Cardiothorac Imaging. 2021;3:e210248.
[10] Wang SY, Juthani PV, Borges KA, et al. Severe breakthrough COVID-19 cases in the SARS-CoV-2 delta (B.1.617.2) variant era. Lancet Microbe. 2022;3:e4–5.
[11] Tai DBG, Shah A, Doubeni CA, et al. The disproportionate impact of COVID-19 on racial and ethnic minorities in the United States. Clin Infect Dis. 2021;72:703–6.
[12] Achrekar GC, Batra K, Urankar Y, et al. Assessing COVID-19 booster hesitancy and its correlates: an early evidence from India. Vaccines (Basel). 2022;10:1048.
[13] van Prooijen JW. Why education predicts decreased belief in conspiracy theories. Appl Cogn Psychol. 2017;31:50–8.
[14] Strathdee SA, Abramovitz D, Vera CF, et al. Predictors of COVID-19 vaccine uptake among people who inject drugs. Vaccine. 2023;41:1916–24.
[15] Stefan N. Metabolic disorders, COVID-19 and vaccine-breakthrough infections. Nat Rev Endocrinol. 2022;18:75–6.
[16] Li H, Cai D, Jiang D, et al. Risk of waning humoral responses after inactivated or subunit recombinant SARS-CoV-2 vaccination in patients with chronic diseases: findings from a prospective observational study in China. J Med Virol. 2023;95:e28434.
[17] Shin J, Toyoda S, Nishitani S, et al. Possible involvement of adipose tissue in patients with older age, obesity, and diabetes with SARS-CoV-2 infection (COVID-19) via GRP78 (BIP/HSPA5): significance of hyperinsulinemia management in COVID-19. Diabetes. 2021;70:2745–55.
[18] Stierman B, Afful J, Carroll MD. National health and nutrition examination survey 2017–March 2020 prepandemic data files development of files and prevalence estimates for selected health outcomes. 2021 Available at: https://stacks.cdc.gov/view/cdc/106273 [access date January 15, 2022].
[19] Aggarwal R, Chiu N, Wadhera RK, et al. Racial/ethnic disparities in hypertension prevalence, awareness, treatment, and control in the United States, 2013 to 2018. Hypertension. 2021;78:1719–26.
[20] ADA. Statistics about diabetes. Available at: https://diabetes.org/about-us/statistics/about-diabetes [access date April 27, 2023].
[21] Hosmer DW Jr, Lemeshow S, Sturdivant RX. Applied Logistic Regression (3rd ed). Hoboken, NJ: Wiley; 2013.

[22] Jassat W, Abdool Karim SS, Ozougwu L, et al. Trends in cases, hospitalizations, and mortality related to the Omicron BA.4/BA.5 subvariants in South Africa. Clin Infect Dis. 2023;76:1468–75.
[23] Nguyen NT, Chinn J, De Ferrante M, et al. Male gender is a predictor of higher mortality in hospitalized adults with COVID-19. PLoS One. 2021;16:e0254066.
[24] de Havenon A, Ney JP, Callaghan B, et al. Characteristics and outcomes Among US patients hospitalized for ischemic stroke before vs during the COVID-19 pandemic. JAMA Netw Open. 2021;4:e2110314.
[25] Myers AK, Kim TS, Zhu X, et al. Predictors of mortality in a multiracial urban cohort of persons with type 2 diabetes and novel coronavirus 19. J Diabetes. 2021;13:430–8.
[26] Tartof SY, Slezak JM, Puzniak L, et al. Analysis of mRNA COVID-19 vaccine uptake Among Immunocompromised Individuals in a Large US Health System. JAMA Netw Open. 2023;6:e2251833.
[27] Garcia P, Montez-Rath ME, Moore H, et al. SARS-CoV-2 vaccine acceptability in patients on hemodialysis: a nationwide survey. J Am Soc Nephrol. 2021;32:1575–81.
[28] Kushner BS, Doyle MB, Khan AS, et al. COVID-19 vaccination status and operative outcomes after kidney transplantation. J Am Coll Surg. 2023;237:139–45.
[29] McGovern I, Bogdanov A, Cappell K, et al. Influenza vaccine uptake in the United States before and during the COVID-19 pandemic. Vaccines (Basel). 2022;10:1610.
[30] Jeon S, Lee YF, Koumi K. COVID-19 vaccination: sociopolitical and economic impact in the United States. Epidemiologia (Basel). 2022;3:502–17.
[31] Kriss JL, Hung M-C, Srivastav A, et al. COVID-19 vaccination coverage, by race and ethnicity — national immunization survey adult COVID module, United States, December 2020–November 2021. Available at: https://www.cdc.gov/mmwr/volumes/71/wr/mm7123a2.htm [access date January 15, 2022].
[32] Zhang W, Wu YY, Wu B. Racial/ethnic disparities in getting COVID-19 vaccine: do age, gender, and education matter? Health Equity. 2022;6:500–7.
[33] Donadio G, Choudhary M, Lindemer E, et al. Counties with lower insurance coverage and housing problems are associated with both slower vaccine rollout and higher COVID-19 incidence. Vaccines (Basel). 2021;9:973.
[34] Gaffney AW, Woolhandler S, Himmelstein DU. Association of uninsurance and VA coverage with the uptake and equity of COVID-19 vaccination: January-March 2021. J Gen Intern Med. 2022;37:1008–11.
[35] Siegel M, Critchfield-Jain I, Boykin M, et al. Racial/ethnic disparities in state-level COVID-19 vaccination rates and their association with structural racism. J Racial Ethn Health Disparities. 2022;9:2361–74.
[36] Costa Clemens SA, Weckx L, Clemens R, et al. Heterologous versus homologous COVID-19 booster vaccination in previous recipients of two doses of CoronaVac COVID-19 vaccine in Brazil (RHH-001): a phase 4, non-inferiority, single blind, randomised study. Lancet. 2022;399:521–9.