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Disparities in Level of Care and Outcomes Among Patients with COVID-19: Associations Between Race/Ethnicity, Social Determinants of Health and Virtual Hospitalization, Inpatient Hospitalization, Intensive Care, and Mortality

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Abstract

Objective To examine the role of race/ethnicity and social determinants of health on COVID-19 care and outcomes for patients within a healthcare system that provided virtual hospital care.

Methods This retrospective cohort study included 12,956 adults who received care for COVID-19 within an integrated healthcare system between 3/1/2020 and 8/31/2020. Multinomial models were used to examine associations between race/ethnicity, insurance, neighborhood deprivation measured by Area Deprivation Index (ADI), and outcomes of interest. Outcomes included (1) highest level of care: virtual observation (VOU), virtual hospitalization (VACU), or inpatient hospitalization; (2) intensive care (ICU); and (3) all-cause 30-day mortality.

Results Patients were 41.8% White, 27.2% Black, and 31.0% Hispanic. Compared to White patients, Black patients had 1.86 higher odds of VACU admission and 1.43 higher odds of inpatient hospitalization (vs. VOU). Hispanic patients had 1.24 higher odds of inpatient hospitalization (vs. VOU). In models stratified by race/ethnicity, Hispanic and Black patients had higher odds of inpatient hospitalization (vs. VOU) if Medicaid insured compared to commercially insured. Hispanic patients living in the most deprived neighborhood had higher odds of inpatient hospitalization, compared to those in the least deprived neighborhood. Black and Hispanic patients had higher odds of ICU admission and 30-day mortality after adjustment for other social determinants.

Conclusions Insurance and ADI were associated with COVID-19 outcomes; however, associations varied by race/ethnicity. Racial/ethnic disparities in outcomes are not fully explained by measured social determinants of health, highlighting the need for further investigation into systemic causes of inequities in COVID-19 outcomes.

Keywords Health disparities · COVID-19 · Virtual hospital · Social determinants of health

Introduction

Not long after the novel coronavirus disease 2019 (COVID-19) reached the USA, state and local public health data revealed that Black and Hispanic persons were being disproportionately impacted with higher rates of COVID-19 and disease burden.[1–3] According to the Centers for Disease Control and Prevention (CDC), the age-adjusted COVID-19 hospitalization rates for Black and Hispanic persons were 2.8 times those of White persons, as of September 9, 2021.[1] Evidence also suggests that Black and Hispanic persons disproportionately account for COVID-19 deaths, representing 15% to 19% of excess deaths, respectively, and

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experiencing over two times the age-adjusted risk of mortality compared to White persons.[2] Observed disparities in disease burden may be driven by societal factors that contribute to an increased risk of exposure to the SARS-CoV-2 virus among racial and ethnic minority populations, along with the higher prevalence of comorbid conditions associated with disease complications.[3] Structural racism has perpetuated social inequities including a higher prevalence of persons of color designated as essential workers and living in multi-generational households, which reduces the ability to social distance and implement other mitigation strategies among vulnerable populations.[4–6].

As COVID-19 cases rose and burdened the healthcare system, many healthcare systems rapidly implemented alternative models to traditional care using telemedicine to safely increase access to acute care for COVID-19. One example is a virtual hospital delivery model, which utilizes telemedicine solutions to provide virtual care and equipment at the patient's home at a level which typically would require inpatient hospitalization.[7–9] Although experts have cautioned that telemedicine solutions may exacerbate inequities by excluding historically underserved patients that lack access to technology resources,[10–12] no prior studies to our knowledge have examined variations in the use of virtual hospital services for COVID-19 care by patient social determinants of health.

The primary aim of this study was to examine racial/ethnic and socioeconomic determinants of levels of care and health outcomes among a large cohort of patients with COVID-19 who received care through an integrated healthcare system that provided a virtual care option to patients with COVID-19. Outcomes included level of care received, 30-day intensive care unit (ICU) admission, and mortality. Social determinants of health included race/ethnicity and insurance status, along with other factors known to affect health such as having access to primary care, and exposure to neighborhood characteristics associated with social risk. This study addresses a current gap in the literature regarding the demographic and social determinants of virtual hospitalization and other levels of care and disease outcomes among COVID-19 patients to further inform an equitable response strategy.

Methods

Setting

Atrium Health is one of the largest vertically integrated health systems in the USA. with approximately 40 acute care hospitals, spanning the Carolinas and Georgia, and more than 400 outpatient clinics based in the Charlotte, NC metropolitan area. Data for this study were limited to patients who were tested for SARS-CoV-2 at an Atrium facility in NC or SC, where the first case of COVID-19 was diagnosed in early March 2020. Atrium Health's Virtual Hospital, known as Atrium Health Hospital at Home, was only available for patients residing in NC and SC. Therefore, patients in Georgia were excluded from this analysis.

Atrium Health Hospital at Home Virtual Hospital

During the study period Atrium Health's Hospital at Home Virtual Hospital for patients with suspected or confirmed COVID-19 consisted of two units: a virtual observation unit (VOU) that provided nursing triage to patients, and a virtual acute unit (VACU).[9–13] The VOU utilized nurse check-in and triage, as well as an electronic App to communicate daily symptom logs for nurses to review and flag for concerning symptoms. The VACU utilized a robust virtual care platform and multidisciplinary group of hospitalists, nurses, and community paramedics to provide acutely ill patients with in-home paramedic and virtual hospitalist visits, 24/7 nursing support, and access to intravenous medications, respiratory support, and ongoing diagnostic and monitoring tools.

Patients who tested positive for SARS-CoV-2 or had suspected COVID-19 were triaged to determined illness severity and risks for complication and disease advancement based on multiple clinical criteria.[9] Based on their triage score, patients were deemed appropriate for one of three care levels: (1) VOU, due to having mild illness; (2) VACU, due to moderate illness severity necessitating IV treatments, respiratory support, nurse, or hospitalist follow-up that could be provided in the home environment; or (3) inpatient (brick and mortar) hospitalization, due to patient having severe or critical illness severity (including requiring more than 5 l of supplemental O2 or significant comorbid disease) or a preference for inpatient care when eligible for VACU. Finally, although all positive patients were eligible for at least VOU, there were patients who did not choose enroll in VOU; we will refer to these patients as "no additional care" as they did not receive additional VOU, VACU, or inpatient care from medical personnel after positive test. Accordingly, the care levels generally reflect severity of COVID-19 disease and level of care received.

Study Design and Participants

We conducted a retrospective cohort study of 12,956 patients aged ≥ 18 years old who received care at any Atrium Health facility in NC or SC between March 1, 2020, and August 31, 2020. Patients with a positive SARS-CoV-2 reverse-transcriptase polymerase chain reaction (RT-PCR) laboratory test result were included in the study. Patients were excluded if they were tested in a

skilled nursing, long-term care, or rehabilitation facility, or if they were tested as part of an established inpatient stay or procedure, as these may have limited their ability to receive care through the Virtual Hospital. Patients living outside of NC and SC, and those with a P.O. Box or missing address were excluded. All patients tested for SARS-CoV-2 were tracked in a prospective registry linked with the health system electronic medical record (EMR) to collect demographics including residential census tract, prior medical conditions, and COVID-19 outcomes.

Main Measures

The primary outcome of interest was level of care received. Level of care was measured as the highest level of care received within 30-days of a positive SARS-CoV-2 test. Options for level of care from the lowest level to highest level were as follows: (1) no additional virtual or hospital care following positive test, (2) virtual observation unit (VOU), (3) VACU (virtual acute unit), or (4) inpatient (brick and mortar) hospital admission.

The secondary outcome measures were intensive care unit (ICU) admission, and all-cause mortality within 30-days of a patient's first positive SARS-CoV-2 test. Patients with an ICU admission were defined as those receiving a bed order for the ICU within 30 days of a positive COVID test. All-cause mortality was defined as 30-day mortality, using the Social Security Admission (SSA) death date as the index for calculation.

The primary explanatory variable of interest was patient reported race/ethnicity, which was captured as a predefined field in the EMR. Variables extracted from the registry to measure social determinants of health included insurance status (commercial, Medicare, Medicaid, and self-pay/uninsured) and patient address to determine the Area Deprivation Index (ADI).[14, 15] The ADI is a factor-based score that ranks neighborhoods by social and economic disadvantage, incorporating 17 indicators of poverty, educational attainment, and housing quality.[15] We used American Community Survey 5-year 2014–2018 estimates to calculate a localized ADI by census tract for each state (NC, SC separately using the larger state as a reference group).[16] The continuous ADI score was grouped into quintiles (Q1–Q5) for analysis, with Q1 representing affluent communities with the lowest level of exposure to social and health risk factors and merged with the patient dataset by census tract.

We also extracted patient comorbidities from the EMR, which were used to calculate the Charlson Comorbidity Index (CCI).[17] EMR data were also used to determine whether patients had an attributed primary care provider (PCP). Patient sex and age were also included as covariates.

Statistical Analysis

Continuous variables were reported as means and standard deviations, and categorical variables were expressed as proportions. Multinomial logit regression analysis was used to assess the associations between level of care and race/ethnicity and other explanatory variables. The virtual observation level was chosen as the reference category due to the ease of comparison of this level to the virtual acute and inpatient stay levels. The heterogeneous nature of the lowest level of care, discharge home with no additional care, made comparisons to other levels impractical and disqualified it from being the reference level. The multinomial logit model was chosen over an ordered probit model because the proportional odds assumption was not met, $\chi^2 = 7567.07$, df = 82, $p = 0.001$. The model was adjusted for insurance status, ADI, age, CCI, sex, and having a primary care provider. The sample was then stratified by race/ethnicity, and the adjusted model was estimated separately for White, Black, and Hispanic populations. We calculated a post hoc model and goodness of fit on each stratified model, all of which confirmed the final models fit the data better than an intercept only model;[18] Pearsons and Deviance goodness of fit were all non-significant. Logistic regression models were used to test the association between ICU admission and race/ethnicity and between 30-day mortality and race/ethnicity. Models were adjusted for insurance status, ADI, age, gender, CCI, and having a PCP. Estimates were reported as odds ratios with their corresponding 95% confidence intervals. Analyses were conducted using SPSS v. 26; ADI was estimated using the R "sociome" package.[19].

Results

Demographic, Community, and Clinical Characteristics

Between March 1 and August 31, 2020, there were 12,956 confirmed COVID-19 cases, including 5422 (41.8%) White, 3519 (27.2%) Black, and 4015 (31.0%) Hispanic patients who met our inclusion criteria. Demographic, community, and clinical characteristics of the sample by race/ethnicity including sex and age group are shown in Table 1. Non-Hispanic White patients had a mean age of 47.1 (standard deviation [SD] = 17.21) with a significantly lower mean age for Hispanic patients (mean 38.6, $SD = 13.1$) and for Black patients ($M = 44.5$, $SD = 16.7$). Hispanic patients had a significantly lower mean CCI score ($M = 0.28$, $SD = 0.91$), while Black patients had significantly higher mean CCI scores ($M = 0.96$, $SD = 1.88$) than White patients ($M = 0.72$, $SD = 1.53$). For insurance type, White patients had a higher proportion of commercial insurance and lower proportion of

Table 1 Baseline characteristics of COVID-19 positive patients by race/ethnicity ($n = 12{,}956$)

Patient characteristics:	Total $n = 12{,}956$	Non-Hispanic White $n = 5422$	Non-Hispanic Black $n = 3519$	Hispanic $n = 4015$	p-value
n (%)					
Sex					
Male	6427 (46.1)	2792_a (47.5)	1506_b (40)	2129_a (49.5)	$p < .001$
Age (years), mean (SD)					
		47_a (18.8)	44.5_b (16.6)	38.6_c (13.1)	$p < .001$
Age group, years					
18–29	3228 (24.9)	1278_a (23.6)	820_a (23.3)	1130_b (28.1)	$p < .001$
30–39	2638 (20.4)	836_a (15.4)	681_b (19.4)	1121_c (27.9)	
40–49	2542 (19.6)	888_a (16.4)	673_b (19.1)	981_c (24.4)	
50–59	2117 (16.3)	969_a (17.9)	645_a (18.3)	503_b (12.5)	
60–69	1289 (9.9)	693_a (12.8)	407_a (11.6)	189_b (4.7)	
> 70	1142 (8.8)	758_a (14.0)	293_b (8.3)	91_c (2.3)	
Insurance type					
Uninsured/self-pay	4073 (31.4)	565_a (10.4)	629_b (17.9)	2879_c (71.7)	$p = .000$
Medicaid	1072 (8.3)	264_a (4.9)	511_b (14.5)	297_c (7.4)	
Medicare	1773 (13.7)	1093_a (20.2)	593_b (16.9)	87_c (2.2)	
Commercial	6038 (46.6)	3500_a (64.6)	1786_b (50.8)	752_c (18.7)	
Area Deprivation Index (ADI)					
Q1	2487 (19.2)	1574_a (29.0)	531_b (15.1)	382_c (9.5)	$p = .000$
Q2	2546 (19.7)	1126_a (20.8)	707_a (20.1)	713_b (17.8)	
Q3	2334 (18.0)	1175_a (21.7)	465_b (13.2)	694_c (17.3)	
Q4	2574 (19.9)	1037_a (19.1)	825_b (23.4)	712_a (17.7)	
Q5	3015 (23.3)	510_a (9.4)	991_b (28.2)	1514_c (37.7)	
Has primary care provider (PCP)					
Yes	5517 (42.6)	2838_a (52.3)	1726_b (49.0)	953_c (23.7)	$p < .001$
Charlson Comorbidity Index score, CCI mean (SD)					
	.66 (1.52)	$.72_a$ (1.53)	$.96_b$ (1.88)	$.28_c$ (0.91)	$p < .01$
Care level					
No additional care	606 (4.7)	419_a (7.7)	122_b (3.5)	65_c (1.6)	$p < .001$
Virtual observation (VOU)	10,590 (81.7)	4287_a (79.1)	2759_a (78.4)	3544_b (88.3)	
Virtual acute (VACU)	156 (1.2)	65_a (1.1)	65_b (1.9)	26_c (0.6)	
Inpatient hospitalization	1604 (12.4)	651_a (12.0)	573_b (16.3)	380_c (9.5)	
30-day intensive care unit (ICU) admission					
Yes	550 (4.2)	230_a (4.2)	191_b (5.4)	129_c (3.2)	$p < .001$
30-day all-cause mortality					
Yes	197 (1.5)	117_a (2.2)	57_a (1.6)	23_b (0.6)	$p < .001$

Notes: Cell values for all categorical variables are frequencies and proportions. Values with a subscript denote a significant difference between column variable groups based on chi-square Bonferroni calculations $p < .05$. Values within each row with different superscripts are significantly different

Medicare and Medicaid than Black and Hispanic patients. Black patients had significantly higher proportion of Medicaid than White patients. The proportion of patients that were self-pay was greatest for Hispanics. Patients living in a community with an ADI in Q1(least deprived) were disproportionately White (29.0%) compared to Black (15.1%) and Hispanic (9.5%), while those living in Q5 (most deprived) were disproportionately Black (28.2%) and Hispanic (37.3%) compared to White (9.4%). Close to 50% of White and Black patients had a PCP, while only 23.7% of Hispanics had a documented PCP.

Table 2 reports the outcomes by race/ethnicity, age, and community and clinical characteristics. ICU admission was significantly different for all racial/ethnic groups. Hispanic patients had significantly lower 30-day mortality than Black or White patients. Higher proportions of White and Black patients received VOU versus the other levels of care. Black patients had the highest proportion of VACU stay (40.1%),

Table 2 Baseline characteristics of COVID-19-positive patients by outcomes ($n = 12{,}956$)

Patient characteristics:	No additional care $n = 606$	Virtual observation (VOU) $n = 10{,}590$	Virtual acute (VACU) $n = 156$	Inpatient hospital $n = 1604$	30-day ICU admission $n = 550$	30-day mortality $n = 197$
n (%)						
Race/ethnicity						
Non-Hispanic White	419_{a} (69.1)	4287_{b} (40.5)	65_{b} (41.7)	651_{b} (40.6)	230 (41.8)	117 (59.4)
Non-Hispanic Black	122_{a} (20.1)	2759_{b} (26.1)	65_{c} (41.7)	573_{c} (35.7)	191 (34.7)	57 (28.9)
Hispanic	65_{a} (10.7)	3544_{b} (33.5)	$26_{a,c}$ (16.7)	380_{c} (23.7)	129 (23.5)	23 (11.7)
Sex						
Male	261_{a} (43.1)	4855_{a} (45.8)	67_{a} (42.9)	785_{a} (48.9)	303 (55.1)	98* (49.7)
Age group, years						
18–29	108_{a} (17.8)	2996_{b} (28.3)	5_{c} (3.2)	119_{c} (7.4)	12 (2.2)	0 (0.0)
30–39	93_{a} (15.3)	2358_{b} (22.3)	$23_{a,b,c}$ (14.7)	164_{c} (10.2)	49 (8.9)	5 (2.5)
40–49	97_{a} (16.0)	2204_{b} (20.8)	$31_{a,b}$ (19.6)	210_{a} (13.1)	71 (12.9)	7 (3.6)
50–59	$105_{a,b}$ (17.3)	1666_{b} (15.7)	37_{a} (23.7)	309_{a} (19.3)	107 (19.5)	21 (10.7)
60–69	80_{a} (13.4)	868_{b} (8.2)	34_{c} (21.8)	307_{c} (19.1)	130 (23.6)	36 (18.3)
> 70	123_{a} (20.3)	498_{b} (4.7)	26_{a} (16.7)	495_{c} (30.9)	181 (32.9)	128 (65.0)
Insurance type						
Self-pay	73_{a} (12.0)	3607_{b} (34.1)	$30_{a,c}$ (19.2)	274_{a} (16.4)	116 (21.1)	19 (9.6)
Medicaid	47_{a} (7.8)	867_{a} (8.2)	8_{a} (5.1)	129_{a} (7.7)	47 (8.5)	10 (5.1)
Medicare	162_{a} (26.7)	866_{b} (8.4)	$68_{a,b}$ (41.7)	839_{b} (50.1)	265 (48.2)	152 (77.2)
Commercial	324_{a} (53.5)	5230_{a} (49.4)	78_{a} (47.9)	432_{b} (25.8)	122 (22.2)	16 (8.1)
Area Deprivation Index (ADI)						
Q1	$95_{a,b}$ (15.7)	2117_{b} (20.0)	$32_{a,b}$ (20.5)	243_{a} (15.1)	73 (13.3)	36* (18.3)
Q2	68_{a} (11.2)	2152_{b} (20.3)	33_{b} (21.2)	293_{b} (18.3)	98 (17.8)	40 (20.3)
Q3	154_{a} (25.4)	1853_{b} (17.5)	$27_{a,b}$ (17.3)	300_{b} (18.7)	105 (19.1)	36 (18.3)
Q4	196_{a} (32.3)	1994_{b} (18.8)	$32_{b,c}$ (20.5)	352_{c} (21.9)	142 (25.8)	43 (21.8)
Q5	93_{a} (15.3)	2474_{b} (23.4)	$32_{a,b}$ (20.5)	416_{b} (25.9)	142 (25.8)	42 (21.3)
Has primary care provider (PCP)						
Yes	$266_{a,b,c}$ (40.2)	4531_{c} (42.8)	86_{b} (55.1)	$634_{a,c}$ (39.5)	223 (40.5)	73* (37.1)

Notes: *ICU*, intensive care unit; Cell values for all categorical variables are frequencies and proportions. *Proportions for 30-day mortality, ADI, and PCP are significantly different between groups. Values with different subscripts denote a significant difference between column variable group based on chi-square Bonferroni calculations $p < .05$. Values within each row with different superscripts are significantly different. Care level and 30-day all-cause mortality are for all COVID-positive patients. Thirty-day ICU admission only includes patients who were hospitalized with COVID-19. Care level is the highest level of care received 30-day post-COVID diagnosis

followed by inpatient stay (35.7%), compared to White or Hispanic patients. Hispanic patients had a greater proportion of VOU (33.5%) than inpatient (23.7%) and VACU (16.7%), and had the lowest proportion of patients without additional care (10.7%) compared to White and Black patients. ICU admission and all-cause mortality were highest among White patients (41.8% and 59.4% respectively), followed by Black (34.7%, 28.9%), and Hispanic (23.5%, 11.7%) patients.

Modeling Levels of Care for COVID Patients

The full model (Table 3) shows the adjusted odds of each level of care compared to VOU. After adjusting for patient characteristics, compared to White patients, Black patients had 86% higher odds of being admitted to VACU (vs. VOU) (odds ratio [OR] = 1.86; 95% confidence interval [CI] 1.29–2.69) and 43% higher odds of being admitted to inpatient care (OR = 1.43; 95%CI 1.23–1.67). Besides age and CCI, which both increased the odds of being admitted to VACU, the only other factor associated with VACU admission was race/ethnicity. Compared to White patients, Hispanic patients had 24% higher odds of being admitted to inpatient care (OR = 1.24; 95%CI 1.02–1.49). Among self-pay patients, the odds of receiving no additional care (vs. VOU) were significantly lower (OR = 0.52; 95%CI 0.38–0.70), and the odds of receiving inpatient care were significantly higher (OR = 1.25; 95%CI 1.04–1.52) compared to those with commercial insurance. The odds of being admitted to inpatient (vs. VOU) were significantly higher

Table 3 Multinomial models predicting level of care in COVID-positive patients compared to virtual observation (VOU) by patient characteristics

	No additional care	Virtual acute (VACU)	Inpatient hospitalization
Full model 1 (vs. virtual observation, VOU)	OR (CI)	OR (CI)	OR(CI)
Race/ethnicity (ref = White)			
Non-Hispanic Black	0.45 (0.37–0.57)***	1.86 (1.29–2.69)***	1.43 (1.23–1.67)***
Hispanic	0.29 (0.21–0.39)***	0.82 (0.47–1.43)	1.24 (1.02–1.49)*
Insurance type (ref = commercial)			
Self-pay/uninsured	0.52 (0.38–0.70)***	0.97 (0.58–1.63)	1.25 (1.04–1.52)*
Medicaid	1.20 (0.86–1.67)	0.84 (0.40–1.79)	2.08 (1.65–2.63)***
Medicare	1.29 (0.98–1.70)	0.76 (0.46–1.27)	1.69 (1.39–2.05)***
Area Deprivation Index (ADI) (ref = Q1)			
Q2	0.87 (0.63–1.21)	1.06 (0.64–1.74)	1.16 (0.94–1.42)
Q3	2.18 (1.66–2.85)***	1.04 (0.62–1.76)	1.31 (1.07–1.62)*
Q4	2.69 (2.07–3.48)***	1.01 (0.61–1.67)	1.29 (1.06–1.58)**
Q5	1.67 (1.23–2.28)*	1.03 (0.61–1.73)	1.40 (1.14–1.71)**
Has primary care provider (PCP)			
Yes	0.63 (0.53–0.75)***	1.15 (0.81–1.62)	0.56 (0.49–0.64)***
Sex (ref=female)			
Male	0.90 (0.75–1.06)	0.95 (0.69–1.32)	1.12 (0.99–1.26)
Age	1.02 (1.02–1.15)***	1.05 (1.04–1.07)***	1.04 (1.04–1.05)***
Charlson Comorbidity Index, CCI	1.08 (1.01–1.15)*	1.13 (1.02–1.26)*	1.43 (1.39–1.49)***
Stratified model 2: non-Hispanic White race/ethnicity			
Insurance type (ref = Commercial)			
Self-pay/uninsured	0.31 (0.19–0.52)***	0.22 (0.03–1.62)	1.19 (0.81–1.73)
Medicaid	1.17 (0.73–1.87)	0.49 (0.07–3.66)	2.47 (1.58–3.86)***
Medicare	1.33 (0.95–1.85)	0.70 (0.33–1.52)	1.77 (1.31–2.40)***
Area Deprivation Index (ADI) (ref = Q1)			
Q2	0.66 (0.44–0.99)*	1.04 (0.53–2.03)	1.19 (0.89–1.60)
Q3	2.28 (1.68–3.09)***	0.86 (0.42–1.77)	1.42 (1.07–1.89)*
Q4	3.11 (2.31–4.19)***	0.98 (0.49–1.99)	1.39 (1.05–1.85)*
Q5	2.02 (1.35–3.02)*	0.80 (0.27–2.36)	1.58 (1.10–2.27)*
Has primary care provider (PCP)			
Yes	0.44 (0.35–0.54)***	1.23 (0.72–2.12)	0.42 (0.34–0.51)***
Sex (ref=female)			
Male	0.82 (0.66–1.01)	0.91 (0.55–1.50)	1.25 (1.03–1.51)*
Age	1.02 (1.02–1.03)***	1.05 (1.02–1.07)***	1.05 (1.04–1.06)***
CCI	1.03 (0.95–1.12)	1.23 (1.07–1.41)*	1.39 (1.32–1.46)***
Stratified model 3: non-Hispanic Black race/ethnicity			
Insurance type (ref = commercial)			
Self-pay/uninsured	0.97 (0.54–1.74)	0.95 (0.44–2.06)	1.09 (0.79–1.52)
Medicaid	1.38 (0.77–2.15)	1.13 (0.48–2.67)	1.79 (1.28–2.49)***
Medicare	1.02 (0.57–1.83)	0.93 (0.43–2.03)	1.68 (1.23–2.93)**
Area Deprivation Index (ADI) (ref = Q1)			
Q2	1.50 (0.76–2.97)	1.11 (0.47–2.64)	0.99 (0.68–1.45)
Q3	2.28 (1.14–4.54)*	1.30 (0.52–3.26)	1.24 (0.84–1.85)
Q4	1.11 (0.55–2.22)	1.14 (0.50–2.62)	0.99 (0.69–1.42)
Q5	1.47 (0.76–2.84)	1.08 (.047–2.47)	1.14 (0.81–1.61)
Has primary care provider (PCP)			
Yes	1.22 (0.83–1.80)	0.95 (0.57–1.59)	0.58 (0.46–0.72)***
Sex			
Male	1.04 (0.71–1.53)	1.07 (0.64–1.79)	0.15 (0.93–1.43)

Table 3 (continued)

	No additional care	Virtual acute (VACU)	Inpatient hospitalization
Age	1.03 (1.02–1.05)***	1.04 (1.02–1.06)***	1.04 (1.03–1.05)***
CCI	1.14 (1.01–1.28)*	1.04 (0.87–1.24)	1.45 (1.37–1.54)***
Stratified model 4: Hispanic race/ethnicity			
Insurance type (ref = commercial)			
Self-pay/uninsured	0.98 (0.50–1.89)	2.16 (0.70–6.76)	1.64 (1.18–2.30)*
Medicaid	1.63 (0.62–4.30)	———————-	2.22 (1.32–3.73)*
Medicare	2.56 (0.70–9.34)	1.25 (0.19–8.32)	1.56 (0.85–2.85)
Area Deprivation Index (ADI) (ref = Q1)			
Q2	0.85 (0.24–30.5)	1.37 (0.26–7.31)	1.36 (0.82–2.28)
Q3	1.53 (0.47–4.93)	1.50 (0.28–8.04)	1.37 (0.82–2.28)
Q4	4.32 (1.50–12.44)*	0.84 (0.14–5.18)	1.62 (0.98–2.67)
Q5	1.13 (0.37–3.44)	1.56 (0.33–7.34)	1.61 (1.01–2.57)*
Has primary care provider (PCP)			
Yes	1.73 (0.96–3.13)	1.79 (0.71–4.50)	0.99 (0.74–1.32)
Sex (ref=female)			
Male	1.42 (0.85–2.40)	0.83 (0.37–1.84)	1.00 (0.79–1.26)
Age	1.00 (0.99–1.03)	1.08 (1.04–1.11)***	1.05 (1.04–1.06)***
CCI	1.10 (0.84–1.46)	1.06 (0.70–1.60)	1.52 (1.39–1.67)***

***$p < .001$; **$p < .01$; *$p < .05$; model 1 is the full multinomial model with non-Hispanic White patients as the reference group; models 2–4 are stratified multinomial regressions within race/ethnicity. *Ref*, reference category. Empty cell values for Medicaid are due to *n*'s too low to estimate reliably

among Medicaid and Medicare patients compared to commercially insured patients. Overall, ADI quintile area was significantly associated with both increased odds of receiving no additional care and increased odds of being admitted inpatient (vs. VOU) for patients living in the most deprived communities (ADI Q3–Q5) compared to those living in the least deprived communities (ADI Q1). Having a PCP was associated with approximately 50% lower odds of being admitted inpatient (vs. VOU; OR = 0.56; 95%CI 0.49–0.64). Increased age and higher CCI scores were associated with significantly higher odds of all care levels compared to VOU.

Stratified Models by Race/Ethnicity

In the models stratified by race/ethnicity (Table 3), among White patients, self-pay patients had 69% lower odds of receiving no additional care (OR = 0.31; 95%CI 0.19–0.52) and 19% higher odds of being admitted inpatient (OR = 1.19; 95%CI 0.81–1.73) than VOU compared to patients with commercial insurance. White patients with Medicaid had the highest odds of being admitted inpatient (OR = 2.47; 95%CI = 1.58–3.86) compared to any other insurance type. The effect of ADI for White patients differed from that of Hispanic and Black patients. While ADI did not increase the odds of VACU admission, White patients living in a deprived community Q3–Q5 (vs. Q1) had higher odds of being admitted inpatient and sent home without additional care (vs. VOU). Living in an ADI Q2 census tract compared to ADI Q1 decreased the odds of being sent home without additional care for White patients. White males had higher odds of inpatient admission and lower odds of receiving VACU and no additional care compared to VOU.

For Black patients, insurance status was the only social determinant of health that predicted greater odds of inpatient admission. Black patients with Medicaid (OR = 1.79, 95%CI 1.28–2.49) or Medicare insurance (OR 1.68, 95%CI 1.12–2.93) had increased odds of being admitted inpatient compared to commercial insured. Unlike for White patients, ADI was generally not a significant predictor of care level received. For Black patients, having a documented PCP was associated with 42% lower odds of inpatient admission compared to VOU compared to those without a PCP (OR = 0.58; 95%CI 0.46–0.72). Increased age and higher CCI both increased the odds of receiving any care other than VOU.

Hispanic patients were more than twice as likely to be admitted inpatient (vs. VOU) if they had Medicaid (OR = 2.22; 95%CI = 1.32–3.73) and had 64% higher odds of inpatient admission if they were self-pay patients (OR = 1.64; 95%CI = 1.18–2.30) compared to those with commercial insurance. The odds of being admitted inpatient (vs. VOU) were 61% higher among Hispanic patients living the most deprived community (Q5) than among those living in the least deprived communities (Q1, OR = 1.61, 95%CI 1.01–2.57). Having a PCP did not significantly influence the level of care received by Hispanic patients. Older age was associated with 52% increased

odds of being admitted to VACU and inpatient versus VOU. CCI significantly increased the odds of inpatient admission (OR = 1.52; 95%CI = 1.39–1.67) compared to VOU.

Intensive Care Unit Admission and 30-Day Mortality

Both Black and Hispanic patients had significantly higher odds of ICU admission and 30-day all-cause mortality (Table 4) compared to White patients. Of the social determinants of health examined, insurance type was the largest predictor of having an ICU admission or mortality 30-days post positive COVID test. Self-pay patients had 26% higher odds of being admitted to the ICU than commercial patients. All insurance types were associated with higher odds of mortality compared to commercial insurance, ranging from 1.28 times the odds for self-pay patients, to 2.05 times the odds for Medicaid patients. Having a PCP was associated with lower odds of ICU admission (OR = 0.73; 95%CI 0.60–0.89) and mortality (OR = 0.59; 95%CI 0.52–0.67). Being male, older age, and higher CCI were associated with greater odds of both ICU admission and mortality.

Discussion

Consistent with previous literature showing greater COVID-19 illness severity and higher rates of hospitalization for minority racial/ethnic groups,[20–22] in this study, Black and Hispanic patients had higher odds of inpatient hospitalization and lower odds of receiving no additional care compared to White patients. Black patients also were more likely to be admitted to VACU compared to White patients. We found differences in ICU admission and 30-day mortality were not only associated with age and CCI score, but also race/ethnicity, insurance status, ADI, and having a PCP. Older age was consistently associated with increased odds of VACU and inpatient hospitalization across models stratified by race/ethnicity. This study provides evidence of a virtual care model that was utilized by a diverse patient population, while highlighting social factors including insurance status and neighborhood deprivation that impact level of care and the value of having a primary care provider relationship.

Our study found that Black and Hispanic patients had a higher risk of ICU admission and death within 30 days of the first positive SARS-CoV-2 test compared to White patients. Having any other insurance type in our study compared to

Table 4 Patient characteristics associated with 30-day intensive care unit (ICU) admission and mortality

	30-day ICU admission (model 5; $n = 1604$)	30-day all-cause mortality (model 6; $n = 12{,}956$)
Race/ethnicity (ref = non-Hispanic White)	OR (95%CI)	
Non-Hispanic Black	1.38 (1.11–1.73)**	1.53 (1.32–1.78)**
Hispanic	1.47 (1.09–1.98)*	1.35 (1.12–1.63)***
Insurance type (ref = commercial)		
Self-pay/uninsured	1.26 (0.92–1.73)	1.28 (1.06–1.55)*
Medicaid	1.89 (1.30–2.75)***	2.05 (1.63–2.59)***
Medicare	1.68 (1.25–2.27)***	1.60 (1.32–1.94)***
Area Deprivation Index, ADI (ref = Q1)		
Q2	1.33 (0.96–1.85)	1.16 (0.94–1.42)
Q3	1.43 (1.04–1.98)*	1.23 (1.00–1.51)
Q4	1.54 (1.13–2.11)**	1.18 (0.97–1.44)
Q5	1.57 (1.14–2.16)**	1.33 (1.09–1.63)**
Has primary care provider (PCP)		
Yes	0.73 (0.60–0.89)***	0.59 (0.52–0.67)***
Sex		
Male	1.46 (1.22–1.76)***	1.13 (1.00–1.28)*
Age (ref=female)	1.04 (1.03–1.05)***	1.04 (1.04–1.05)***
Charlson Comorbidity Index, CCI	1.26 (1.22–1.31)***	1.41 (1.37–1.46)***

Notes: *ref*, reference category; logistic regression model 5: reference group is inpatient hospitalized patients without an ICU admission within 30 days of the first positive COVID-19 test; *n*, hospitalized patient sample. Logistic regression model 6: reference group is all COVID-positive patients without mortality within 30 days of the first positive COVID-19 test; *n*, total study sample. *$p < .05$; **$p < .01$; ***$p < .001$

commercial insurance was also significantly associated with increased odds of ICU admission and 30-day mortality. Several studies, including a systematic review examining differences in COVID-19 outcomes by race/ethnicity, have found a similar pattern in disparities, in which Black or Hispanic patients face higher hospitalization and mortality rates.[20, 22–25] Yet other studies have reported no racial/ethnic differences in case-fatality mortality rates.[20, 26, 27] Despite these differences in findings related to mortality, the literature has consistently shown increased risk of severe illness in racial/ethnic minority populations.[25] In our study sample, Black and Hispanic patients were more likely to be enrolled in VOU compared to being discharged home without additional care. This suggests that even among those cared for in outpatient settings, there was higher disease severity (based on care level) compared to White patients. The underlying reason for increased severity requires further study, although some suggest that the comorbidity burden among minority patients contributes more tenuous clinical presentations.[28] Other unmeasured factors, like time of presentation to care, may also contribute to these findings. Populations with access barriers or competing demands stemming from structural inequalities [29] may be more likely to delay care for their acute health concerns and thus be more ill upon presentation.

Our study included stratified analyses to better understand additional social determinants of health that may be associated with increased odds of hospitalization at the various care levels among different racial/ethnic groups. In all models stratified by race/ethnicity, insurance status was significantly associated with odds of inpatient hospitalization. Specifically, we found that Black and Hispanic patients who were Medicaid insured were more likely to be admitted to inpatient hospitalization versus VOU compared to those who were commercially insured. Neither insurance status nor ADI were significantly associated with VACU in the stratified (or full) models. As such, our models cannot fully explain why the odds of VACU admission compared to VOU were increased in Black patients compared to White patients. One possible explanation is that Black patients were determined by care providers to be at increased risk of severe illness or at risk for disease progression with COVID-19 compared to White patients, even among those patients who did not require inpatient hospitalization. This may have been secondary to studies early in the pandemic that demonstrated patterns of more severe COVID-19 illness in Black patients.[30, 31] Further study including qualitative data that explores provider clinical decision-making may better elucidate these relationships.

Interestingly, there seemed to be a more significant effect of neighborhood deprivation on hospitalization for White patients than for Black or Hispanic patients in the models stratified by race/ethnicity. These results are similar to other studies demonstrating stronger predictive relationships between ADI and poor health outcomes among White patients compared to Black patients.[22, 32, 33] Living in a deprived community exposes an individual resident, regardless of their race or ethnicity, to the cumulative effects of area poverty and subsequently impacts health outcomes.[34] However, for racial/ethnic minority patients, the lack of association of outcomes in the present study with ADI suggests that there are likely additional unmeasured social determinants of health that are based in structural racism and inequality that contribute to the observed disparity in hospitalizations.

Notably, we did identify other patient factors that were consistently associated with inpatient hospitalization for Black and Hispanic patients in the stratified models, namely age, CCI score, and having a PCP. Black and Hispanic patients were more likely to be admitted to an inpatient hospital with increasing CCI score, which is an index of comorbidities known to be associated with COVID-19 severity.[17] Having a PCP lowered the risk of inpatient hospitalization for Black and White patients. Having a PCP was also associated with decreased odds of 30-day mortality. This suggests that prior engagement with the medical system through primary care has a protective role in need for inpatient hospitalization and critical illness. This may represent a potential area of focus for interventions to mitigate health disparities for Black patients, whose PCP attribution rate in our sample was lower, and to improve COVID-19 outcomes for all patients. Existing evidence supports the role of PCPs and the patient-PCP relationship in improving chronic disease control and reducing emergency department visits through better preventive care and disease management to prevent adverse outcomes.[34–36] A similar pattern could also be at work among COVID-19 patients and how a relationship with primary care impacts the examined outcomes.

A unique aspect of our study is the inclusion of virtual observation and virtual hospitalization as care options and the ability to examine the association of race/ethnicity, insurance status, ADI, and other characteristics on likelihood of admission into virtual care. Virtual care options expanded tremendously in response to the pandemic; however, there have been concerns that virtual care access may be limited for certain groups of patients who face barriers to its use due to lacking the necessary technology, internet, or phone access or for those whose primary language is non-English.[10, 12] Prior research demonstrates that these factors are more likely to act as barriers to care for racial/ethnic minority or low-income patients.[11, 37] Our study however found increased utilization of virtual observation compared to no additional care among Black and Hispanic patients compared to White patients. In addition, while insurance status was associated with inpatient hospitalization, in the stratified models, insurance status

was not associated being admitted to VACU or receiving no additional care compared to VOU for Black and Hispanic patients. To be admitted to VACU, patients were only required to have a functioning home telephone, which could be either landline or cell phone. The healthcare system provided all other necessary equipment, including Wi-Fi hot spots, as required by patients. This suggests that virtual care may be an equitable care option for patients if the need to have their own technology equipment is minimal, which shows promise for future applications of virtual care even beyond the pandemic.

Our study results should be interpreted in the context of its limitations. First, the study data is from a single healthcare system located in the Southeast and therefore may not be generalizable to other settings or health systems. However, the Southern region of the USA also has a higher population of racial/ethnic minority patients and lower insurance coverage, making it an important region in which to examine health disparities to inform regional strategies for a targeted response.[38] Second, overall mortality rates and mortality among Hispanic patients were low during the study period, resulting in small sample sizes for our regression analysis for 30-day mortality. Finally, we did not have more granular details on the patient's specific comorbidities or clinical status, such as risk predictor scores for severe pneumonia outcomes,[39] vital signs at the time of presentation, or imaging findings, all of which may have impacted their care level and decisions regarding hospitalization.[9]

Conclusion

Racial/ethnic disparities are present in levels of care and outcomes among patients with COVID-19, which cannot be fully explained by additional social determinants of health including insurance status and neighborhood social risk. However, virtual hospitalization is a promising alternative care model for moderately to severely ill patients that may address inequities in access with attention to technological barriers. Future research should examine the role of structural racism in healthcare outcomes for Black and Hispanic patients, and the additional potential applications of virtual care to improve care equity.

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Declarations

Ethics Atrium Health's Institutional Review Board reviewed and approved this study.

Conflict of Interest The authors declare no competing interests.

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