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Clinical characteristics and social determinants of health associated with 30-day hospital readmissions of patients with COVID-19

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ABSTRACT

COVID-19 readmissions are associated with increased patient mortality and healthcare system strain. This retrospective cohort study of PCR-confirmed COVID-19 positive adults (≥18 years) hospitalized and readmitted within 30 days of discharge from index admission was performed at eight Atlanta hospitals from March to December 2020. The objective was to describe COVID-19 patient-level demographics and clinical characteristics, and community-level social determinants of health (SDoH) that contribute to 30-day readmissions. Demographics, comorbidities, COVID-19 treatment, and discharge disposition data were extracted from the index admission. ZIP codes were linked to a demographic/lifestyle database interpolating to community-level SDoH. Of 7155 patients with COVID-19, 463 (6.5%) had 30-day, unplanned, all-cause hospital readmissions. Statistically significant differences were not found in readmissions stratified by age, sex, race, or ethnicity. Patients with a high-risk Charlson Comorbidity Index had higher odds of readmission (OR 4.8 (95% CI: 2.1 to 11.0)). Remdesivir treatment and intensive care unit (ICU) care were associated with lower odds of readmission (OR 0.5 (95% CI: 0.4 to 0.8) and OR 0.5 (95% CI: 0.4 to 0.7), respectively). Patients residing in communities with larger average household size were less likely to be readmitted (OR 0.7 (95% CI: 0.5 to 0.9). In this cohort, patients who received remdesivir, were cared for in an ICU, and resided in ZIP codes with higher proportions of residents with increased social support had lower odds of readmission. These patient-level factors and community-level SDoH may be used to identify patients with COVID-19 who are at increased risk of readmission.

WHAT IS ALREADY KNOWN ON THIS TOPIC

⇒ At the time of this study, published literature on the contribution of social determinants of health (SDoH) to COVID-19 hospital readmissions was limited. As the number of survivors of an initial COVID-19 hospitalization grows, with associated hospital and healthcare system strain, it is increasingly important to identify clinical characteristics and SDoH associated with readmission of these patients.

WHAT THIS STUDY ADDS

⇒ Our study found that patients who were admitted to the intensive care unit and those who received remdesivir had lower odds of readmission. Patients who resided in communities with larger average household sizes were also less likely to be readmitted.

HOW THIS STUDY MIGHT AFFECT RESEARCH, PRACTICE OR POLICY

⇒ A better understanding of these factors helps inform discharge disposition and outpatient social services needs as well as the development of tools and protocols to aid healthcare systems (especially those with limited resources) in preventing readmissions.

INTRODUCTION

COVID-19 illness disproportionately affects Latinx and Black, Indigenous, and people of color (BIPOC) in the USA, resulting in increased hospitalizations, morbidity, and mortality.[1–14] COVID-19 hospital readmissions are not uncommon,[15–19] are associated with increased mortality (up to 20% in one study),[19] and strain healthcare systems functioning at or above capacity during pandemic surges. One US study using a healthcare database of patients from non-governmental hospitals found that during the first 5 months of the pandemic, among 106,543 surviving patients with an index admission for COVID-19, 9% were readmitted within 2 months and 1.6% had more than one

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readmission.[17] In another cohort of patients admitted to 132 Department of Veterans Affairs (VA) hospitals, of 2179 index COVID-19 hospitalizations, approximately 20% of those who survived were readmitted within 60 days of discharge.[18]

Social determinants of health (SDoH) are the conditions in which people are born, live, grow, work, and age; SDoH include, but are not limited to, socioeconomic status, education, and healthcare access.[20–22] SDoH contribute to increased risk of hospital readmissions.[23–28] Access to transportation, social fragility, and housing instability are also common causes of challenges following hospital discharge.[29] Researchers suggest that SDoH should be included in analyses of factors contributing to hospital readmission, in addition to inpatient quality of care and patient health status.[30] The connection between COVID-19 outcomes and associated patient and population-level SDoH is well-described; however, descriptions of SDoH associated with COVID-19 hospital readmissions are not well-defined.[31 32]

As the number of survivors of an initial COVID-19 hospitalization grows, with associated hospital and healthcare system strain, it is increasingly important to identify clinical characteristics and SDoH associated with readmission of these patients. This study was designed to describe patient-level demographic and clinical characteristics and community-level SDoH that contribute to 30-day hospital readmissions of patients with COVID-19. A better understanding of these factors could help inform discharge disposition and outpatient social service needs as well as the development of tools and protocols to aid healthcare systems (especially those with limited resources) in preventing readmissions. To our knowledge, this is the first study that combines patient-level demographic and clinical characteristics data, including COVID-19 targeted therapeutic use, with community-level SDoH to predict 30-day COVID-19 hospital readmissions.

MATERIALS AND METHODS

This retrospective cohort study included patients with PCR-confirmed COVID-19 who were hospitalized and then readmitted within 30 days (of their index hospitalization discharge day) between March 1, 2020 and December 31, 2020, to one of eight metropolitan (metro) Atlanta area hospitals (six hospitals within an academic healthcare system, one safety-net academic hospital, and a VA hospital). Clinical data for PCR-confirmed COVID-19 positive adult patients (≥18 years old) with non-scheduled hospital readmissions within 30 days of their index admission discharge day were extracted from electronic medical records (via clinical data warehouses and manual chart reviews). Patient demographics (including age, self-reported sex, self-reported race, self-reported ethnicity), healthcare insurance status (Medicare, Medicaid, private, VA, uninsured), and comorbidities (using International Classification of Diseases-10 billing codes) were extracted. Data on receipt of COVID-19-targeted treatment (at least one dose of either dexamethasone or remdesivir), index admission length of stay (LOS) (<7 days, 8–14 days, or >14 days), necessity for intensive care unit (ICU) care, and necessity for mechanical ventilation were also extracted. Index admission discharge disposition (home (self-care), home (with home health services), long-term acute care hospital, skilled nursing facility, hospice (home or inpatient), transfer to another hospital, or other) was also described. Charlson Comorbidity Index (CCI) scores were extracted from each patient's index admission.[33] Incarcerated and pregnant patients were excluded. The main outcome measure was unplanned, all-cause 30-day hospital readmission following an index admission.

Statistical analysis

We performed descriptive analysis of the index admission of the readmitted cohort including demographics, insurance status, comorbidities, COVID-19 treatment (remdesivir, dexamethasone, dexamethasone+remdesivir), necessity for ICU care, necessity for mechanical ventilation, index admission LOS, and discharge disposition. The results were stratified by race and ethnicity. Age matching was performed with age group categories (<45, 45–64, 65–79, and ≥80 years). We used univariate analysis, χ^2 tests, and t-tests to compare race/ethnicity differences in the above sociodemographic characteristics, clinical characteristics (including comorbidities and COVID-19 targeted treatment), LOS, and discharge disposition.

For multivariable analysis we derived a logistic regression model to estimate the adjusted odds ratio (OR) of all-cause 30-day readmission and various patient demographic and clinical characteristics. We used fixed effects to control for confounding variables known to influence the OR of readmission including comorbidities, sex, and CCI. In addition, variables with a p value of less than 0.05 in the logistic regression were selected for model building. All data analysis was conducted using SAS 9.4 software (SAS Institute, Cary, North Carolina, USA).

Social determinants of health analyses

SDoH were evaluated via ESRI Business Analyst Data, a comprehensive demographic and lifestyle database that provides data to help interpolate patients' socioeconomic status.[34] Patient's ZIP code of residence was linked with the ESRI ZIP code–level classification. Analyzed indicators included median net worth, per cent below 100% federal poverty level, marital status, per cent married, per cent never married, highest level of education, average household size, housing affordability index, median home value, neighborhood deprivation index (NDI), wealth index, number of renter-occupied units, health insurance spending, unemployment rate, smoking products spending, food spending, having visited a doctor in last 12 months, childcare, and public/other transportation spending. The NDI included a mix of education, income and poverty, employment, housing, and occupation indicators. The following are general descriptions of each of the NDI indicators pulled from the U.S. Census Bureau's American Community Survey: percentage of adult population with less than a high school diploma, percentage of households earning less than $30,000 per year, percentage of households with below-poverty level income, proportion of civilian non-institutionalized population between 18 and 64 who are unemployed, proportion of households receiving public assistance, percentage of crowded housing, proportion of households headed by women (no men present) with dependent children, and percentage of men in management or professional occupations.

Means for continuous SDoH variables were reported. Two-sample t-tests and analyses of variance were used to determine significant differences between groups (readmitted vs not readmitted). For two-sample t-tests with statistically unequal variances, the Satterthwaite method was applied and reported. All data analyses were conducted using SAS 9.4 software.

RESULTS

Of 7155 patients with PCR-positive COVID-19 hospitalized from March 1 to December 31, 2020, 463 (6.5%) were readmitted within 30 days (table 1). The largest proportion of readmitted patients, 37.6%, were in the age group of 45–64 years. A majority (54.2%) of readmitted patients were men and most were under-represented minorities (68.7%)—non-Hispanic Black (Black) or Hispanic. A predominance of the non-readmitted patients were also Black or Hispanic (67.7%) (online supplemental table 1). Patients who were uninsured comprised 3.2% of the readmitted cohort and those insured via Medicaid comprised 12.3%. Compared with other known race and ethnicities, non-Hispanic white (white) readmitted patients with COVID-19 comprised the lowest proportion of those insured via Medicaid.

Among the readmitted patients with COVID-19, the most common comorbidities were hypertension (74.3%), diabetes (44.3%), and obesity (42.8%). Of the readmitted patients with an available CCI, 82.5% (n=306) had a medium-risk or high-risk score. The readmitted cohort of black patients had the highest proportions of obesity, hypertension, chronic kidney disease (CKD), congestive heart failure, or other cardiovascular disease, compared with others with known race and ethnicity.

Of those readmitted, 22.2% received treatment with remdesivir and 50.3% were treated with dexamethasone during their index hospitalization. Readmitted patients who required ICU care during their index admission comprised 19.7% of the readmitted patients; 7.6% required mechanical ventilation during their index hospitalization. Most (78.7%) readmitted patients were discharged home (with self-care or with home health services) from their index admission.

In the multivariable, age-matched model, there was no statistically significant difference found between readmissions by age groups, sex, race, or ethnicity (table 2). Compared with those with private insurance, patients insured via Medicaid had higher odds of readmission (OR 1.6 (95% CI: 1.0 to 2.6); p=0.07). The comorbidities with higher odds of readmission included hypertension (OR 1.4 (95% CI: 1.1 to 2.0; p=0.04), stages 3 and 4 CKD (OR 2.1 (95% CI: 1.4 to 3.2; p<0.001)), and cancer (OR 4.9 (95% CI: 2.5 to 9.7; p<0.001)). Patients with a high-risk CCI also had higher odds of readmission (OR 4.8 (95% CI: 2.1 to 11.0); p<0.001)). Increased odds of readmission were also noted with each of these comorbidities (and those with high-risk CCI) both in adjusted and non-adjusted modeling (online supplemental table 2).

Patients who received targeted COVID-19 treatment with remdesivir had lower odds of readmission (OR 0.5 (95% CI: 0.4 to 0.8; p<0.001)) as did those who received both remdesivir and dexamethasone during index hospitalization (OR 0.6 (95% CI: 0.4 to 0.7; p=0.002)), compared with those who received dexamethasone alone. There was no decrease in odds of readmission in patients who received dexamethasone alone during their index hospitalization ((OR 0.8 (95% CI: 0.6 to 1.1; p=0.21). Patients who required ICU care or mechanical ventilation during their index hospitalization had lower odds of readmission (OR 0.5 (95% CI: 0.4 to 0.7; p<0.001) and OR 0.3 (95% CI: 0.2 to 0.5; p<0.001)), respectively).

Social determinants of health

Of the total cohort of 7155 patients with COVID-19, ZIP code data were only available for 6782. Using patient-level ZIP codes linked to community-level SDoH, black patients resided in communities with the lowest median net worth, the lowest median home values, and the lowest amount of food spending when compared with white, Hispanic and Asian patients; they also resided in communities with higher percentage of residents living below the federal poverty level (figure 1). The greatest differences between readmitted and non-readmitted patients were noted by Hispanic ethnicity and Asian race. Hispanic patients who were readmitted resided in ZIP codes where the median net worth of Hispanic persons was >US$50 000 higher than those who were not readmitted. Asian readmitted patients, on the other hand, resided in areas with median net worth of >US$50 000 less than non-readmitted Asian patients. Much less of a difference in median net worth was noted between readmitted and non-readmitted black and white patients. Patients residing in areas with higher proportions of residents with associates degrees and larger average household size were less likely to be readmitted (OR 0.004 (95% CI: 0.001 to 0.566) and OR 0.665 (95% CI: 0.481 to 0.92), respectively) (figure 2).

DISCUSSION

One major strength of this study is that this cohort is composed of patients from eight hospitals (including six healthcare-affiliated hospitals, a safety-net hospital, and a VA hospital) within diverse and socioeconomically different sections of the metro Atlanta, Georgia area. Similar to other studies, the disproportionate effect of COVID-19 on BIPOC populations was noted in this study, with black and Hispanic patients accounting for 68.7% of all readmissions and 67.8% of the full cohort. We also noted the significant burden of comorbidities in the readmitted cohort, supporting previous research noting the association between comorbidities and hospital readmissions.[15–19] In our cohort, although obesity was one of the most common comorbidities, regardless of race and ethnicity, it was not associated with higher odds of readmission (OR 0.7 (95% CI 0.5 to 0.9) compared with other comorbidities, including hypertension, stage 3 or 4 CKD, cancer, or those with medium-risk or high-risk CCI. Another retrospective cohort study reported poor outcomes in obese patients, including ICU admissions and need for mechanical ventilation; however, those who survived, similarly, did not have increased risk for hospital admission.[35] In our study, after adjustment, there was no statistically significant difference noted

Table 1 Characteristics of patients with COVID-19 readmitted to eight Metropolitan Atlanta Hospitals (March 2020–December 2020)*

				Readmitted					
	Total population, N=7155, n (%)	Non-readmitted, N=6692, n (%)	Readmitted, N=463, n (%)	White (non-Hispanic), N=96, n (%)	Black (non-Hispanic), N=289, n (%)	Hispanic, N=29, n (%)	Asian, N=13, n (%)	Unknown/other, N=36, n (%)	P value
Age group, years									
<45	1476 (20.6)	1390 (20.8)	86 (18.6)	12 (12.5)	60 (20.8)	5 (17.2)	2 (15.4)	7 (19.4)	0.35
45–64	2834 (39.6)	2660 (39.7)	174 (37.6)	28 (29.2)	110 (38.1)	14 (48.3)	4 (30.8)	18 (50.0)	0.19
65–79	2000 (28.0)	1865 (27.9)	135 (29.2)	32 (33.3)	81 (28.0)	8 (27.6)	6 (46.2)	8 (22.2)	0.26
≥80	845 (11.8)	777 (11.6)	68 (14.7)	24 (25.0)	38 (13.1)	2 (6.9)	1 (7.7)	3 (8.3)	0.04
Sex									
Women	3382 (47.3)	3170 (47.4)	212 (45.8)	42 (43.8)	141 (48.8)	13 (44.8)	7 (53.8)	9 (25.0)	0.06
Men	3772 (52.7)	3521 (52.6)	251 (54.2)	54 (56.3)	148 (51.2)	16 (55.2)	6 (46.2)	27 (75.0)	0.07
Insurance status									
Private insurance (including Kaiser Permanente)	3554 (49.7)	3367 (50.3)	187 (40.4)	55 (57.3)	111 (38.4)	15 (51.7)	1 (7.7)	5 (13.9)	<0.001
Medicare	2280 (31.9)	2103 (31.4)	177 (38.2)	37 (38.5)	126 (43.6)	4 (13.8)	7 (53.8)	3 (8.3)	<0.001
Medicaid	684 (9.6)	627 (9.4)	57 (12.3)	3 (3.1)	43 (14.9)	7 (24.1)	4 (30.8)	0 (0.0)	<0.001
VA	403 (5.6)	376 (5.6)	27 (5.8)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	27 (75.0)	<0.001
Uninsured	234 (3.3)	219 (3.3)	15 (3.2)	1 (1.0)	9 (3.1)	3 (10.3)	1 (7.7)	1 (2.8)	<0.001
Comorbidities									
Obesity	3445 (49.3)	3253 (49.7)	192 (42.8)	38 (40.9)	135 (48.2)	7 (25.0)	6 (46.2)	6 (17.1)	0.002
Hypertension	4588 (64.1)	4244 (63.4)	344 (74.3)	65 (67.7)	226 (78.2)	18 (62.1)	9 (69.2)	26 (72.2)	0.13
Diabetes	2738 (38.3)	2533 (37.9)	205 (44.3)	27 (28.1)	142 (49.1)	12 (41.4)	8 (61.5)	16 (44.4)	0.006
Hyperlipidemia	2461 (34.4)	2276 (34.0)	185 (40.0)	35 (36.5)	105 (36.3)	13 (44.8)	5 (38.5)	27 (75.0)	<0.001
Chronic lung disease	861 (12.0)	793 (11.8)	68 (14.7)	13 (13.5)	39 (13.5)	0 (0.0)	5 (38.5)	11 (30.6)	<0.001
Chronic kidney disease									
Stages 3 and 4	992 (13.9)	884 (13.2)	108 (23.3)	19 (19.8)	74 (25.6)	3 (10.3)	3 (23.1)	9 (25.0)	0.37
Stage 5 and ESRD	450 (6.7)	385 (6.1)	65 (14.9)	4 (4.2)	56 (19.4)	4 (13.8)	0 (0.0)	1 (11.1)	0.003
Chronic congestive heart failure	1364 (19.1)	1220 (18.2)	144 (31.1)	21 (21.9)	100 (34.6)	1 (3.4)	3 (23.1)	19 (52.8)	<0.001
Other cardiovascular disease	2096 (31.0)	1910 (30.2)	186 (42.7)	33 (34.4)	137 (47.4)	9 (31.0)	5 (38.5)	2 (22.2)	0.07
Mental health condition*	1362 (19.0)	1258 (18.8)	104 (22.5)	27 (28.1)	52 (18.0)	5 (17.2)	3 (23.1)	17 (47.2)	<0.001
Cancer	509 (7.1)	458 (6.8)	51 (11.0)	17 (17.7)	24 (8.3)	5 (17.2)	1 (7.7)	4 (11.1)	0.09
HIV	141 (2.0)	133 (2.0)	8 (1.7)	1 (1.0)	7 (2.4)	0 (0.0)	0 (0.0)	0 (0.0)	0.65
Charlson Comorbidity Index†									
0 (low risk)	1803 (31.4)	1738 (32.4)	65 (17.5)	16 (17.8)	34 (15.7)	4 (20.0)	2 (18.2)	9 (26.5)	<0.01
1–3 (medium risk)	3343 (58.2)	3104 (57.8)	239 (64.4)	65 (72.2)	136 (63.0)	15 (75.0)	6 (54.5)	17 (50.0)	<0.01
≥4 (high risk)	597 (10.4)	530 (9.9)	67 (18.1)	9 (10.0)	46 (21.3)	1 (5.0)	3 (27.3)	8 (23.5)	<0.01
Index admission treatment									

Continued

Table 1 Continued

				Readmitted					
	Total population, N=7155, n (%)	**Non-readmitted, N=6692, n (%)**	**Readmitted, N=463, n (%)**	**White (non-Hispanic), N=96, n (%)**	**Black (non-Hispanic), N=289, n (%)**	**Hispanic, N=29, n (%)**	**Asian, N=13, n (%)**	**Unknown/other, N=36, n (%)**	**P value**
Remdesivir	1832 (32.4)	1729 (33.3)	103 (22.2)	31 (32.3)	50 (17.3)	4 (13.8)	7 (53.8)	11 (30.6)	<0.001
Dexamethasone	2943 (52.1)	2710 (52.2)	233 (50.3)	61 (63.5)	133 (46.0)	14 (48.3)	8 (61.5)	17 (47.2)	0.04
Remdesivir and dexamethasone	1559 (24.6)	1485 (23.5)	88 (20.2)	29 (30.2)	45 (15.6)	4 (13.8)	7 (53.8)	3 (33.3)	<0.001
Required intensive care unit	1763 (24.6)	1485 (23.5)	91 (19.7)	12 (12.5)	63 (21.8)	8 (27.6)	3 (23.1)	5 (13.9)	0.20
Required mechanical ventilation	803 (14.2)	768 (14.8)	35 (7.6)	5 (5.2)	25 (8.7)	4 (13.8)	1 (7.7)	0 (0.0)	0.21
Index admission length of stay‡									
≤7 days	4438 (65.7)	4158 (65.8)	280 (64.2)	70 (72.9)	172 (59.5)	23 (79.3)	8 (61.5)	7 (77.8)	<0.01
8–14 days	1174 (17.4)	1089 (17.2)	85 (19.5)	14 (14.6)	63 (21.8)	3 (10.3)	3 (23.1)	2 (22.2)	0.038
>14 days	1140 (16.9)	1069 (16.9)	71 (16.3)	12 (12.5)	54 (18.7)	3 (10.3)	2 (15.4)	0 (0.0)	—
Index admission disposition									
Home (self-care)	4041 (59.8)	3787 (60.0)	254 (58.3)	53 (55.2)	167 (57.8)	24 (82.8)	5 (38.5)	5 (55.6)	<0.001
Home (with home health services)	753 (11.2)	664 (10.5)	89 (20.4)	27 (28.1)	51 (17.6)	3 (10.3)	5 (38.5)	3 (33.3)	0.013
Long-term acute care hospital	94 (1.4)	90 (1.4)	4 (0.9)	0 (0.0)	4 (1.4)	0 (0.0)	0 (0.0)	0 (0.0)	—
Skilled nursing facility	639 (9.5)	577 (9.1)	62 (14.2)	13 (13.5)	47 (16.3)	1 (3.4)	1 (7.7)	0 (0.0)	—
Hospice (home or inpatient)	205 (3.0)	199 (3.2)	6 (1.4)	1 (1.0)	4 (1.4)	0 (0.0)	1 (7.7)	0 (0.0)	—
Transferred to another hospital	286 (4.2)	277 (4.4)	9 (2.1)	1 (1.0)	6 (2.1)	1 (3.4)	1 (7.7)	0 (0.0)	—
Other§	189 (2.8)	177 (2.8)	12 (2.8)	1 (1.0)	10 (3.5)	0 (0.0)	0 (0.0)	1 (11.1)	—

P value for readmitted population only.
*Mental health conditions include depression, anxiety, bipolar disorder, and schizophrenia.
†Charlson Comorbidity Index was not available for the academic safety-net hospital.
‡Length of stay (of index admission) was not available for VA Hospital data.
§Other was the combination of other rehab, left against medical advice or discontinued care and other discharge dispositions not included above.
¶Data from all eight hospitals, including six academic health system hospitals, one academic safety-net hospital, and one VA Hospital.
ESRD, end-stage renal disease; VA, Veterans Administration.

Table 2 Factors associated with COVID-19 readmission to eight metropolitan Atlanta hospitals (March–December 2020)—multivariable regression; age 1:1 match

	Total population, N=926, n (%)	Non-readmitted, N=463, n (%)	Readmitted, N=463, n (%)	Crude model		Adjusted model*	
				OR (95% CI)	P value	OR (95% CI)	P value
Age group, years							
<45	172 (18.6)	86 (18.6)	86 (18.6)	Ref (1.0)		Ref (1.0)	
45–64	348 (37.6)	174 (37.6)	174 (37.6)	1.0 (0.7 to 1.4)	0.99	0.8 (0.5 to 1.2)	0.35
65–79	270 (29.2)	135 (29.2)	135 (29.2)	1.0 (0.7 to 1.5)	0.98	0.7 (0.5 to 1.2)	0.31
≥80	136 (14.7)	68 (14.7)	68 (14.7)	1.0 (0.6 to 1.6)	0.99	0.7 (0.4 to 1.1)	0.14
Sex							
Women	432 (46.7)	220 (47.5)	212 (45.8)	Ref (1.0)		Ref (1.0)	
Men	494 (53.3)	243 (52.5)	251 (54.2)	1.0 (0.8 to 1.3)	0.94	1.0 (0.8 to 1.3)	0.99
Insurance status							
Private Insurance (including Kaiser Permanente)	406 (43.8)	219 (47.3)	187 (40.4)	Ref (1.0)		Ref (1.0)	
Medicare	340 (36.7)	163 (35.2)	177 (38.2)	1.3 (1.0 to 1.7)	0.10	1.1 (0.8 to 1.5)	0.66
Medicaid	94 (10.2)	37 (8.0)	57 (12.3)	1.8 (1.1 to 2.9)	0.01	1.6 (1.0 to 2.6)	0.07
VA	55 (5.9)	28 (6.0)	27 (5.8)	1.1 (0.6 to 2.0)	0.67	1.4 (0.6 to 2.9)	0.42
Uninsured	31 (3.3)	16 (3.5)	15 (3.2)	1.1 (0.5 to 2.3)	0.80	1.1 (0.8 to 1.5)	0.65
Race/ethnicity							
White (non-Hispanic)	183 (19.8)	87 (18.8)	96 (20.7)	Ref (1.0)		Ref (1.0)	
Black (non-Hispanic)	570 (61.6)	281 (60.7)	289 (62.4)	1.0 (0.7 to 1.4)	0.93	0.9 (0.6 to 1.3)	0.51
Hispanic	58 (6.3)	29 (6.3)	29 (6.3)	0.9 (0.5 to 1.5)	0.61	1.0 (0.6 to 1.9)	0.96
Asian	23 (2.5)	10 (2.2)	13 (2.8)	0.9 (0.4 to 2.0)	0.76	0.9 (0.4 to 2.1)	0.85
Other/unknown	92 (9.9)	56 (12.1)	36 (7.8)	0.7 (0.4 to 1.2)	0.20	0.5 (0.2 to 1.1)	0.08
Comorbidities							
Obesity	408 (45.3)	216 (47.8)	192 (42.8)	0.8 (0.6 to 1.1)	0.08	0.7 (0.5 to 0.9)	<0.01
Hypertension	668 (72.1)	324 (70.0)	344 (74.3)	1.6 (1.2 to 2.2)	<0.001	1.4 (1.1 to 2.0)	0.04
Diabetes	394 (42.5)	189 (40.8)	205 (44.3)	1.2 (0.9 to 1.5)	0.18	1.1 (0.8 to 1.5)	0.62
Hyperlipidemia	358 (38.7)	173 (37.4)	185 (40.0)	1.1 (0.9 to 1.5)	0.42	0.8 (0.6 to 1.1)	0.28
Chronic lung disease	127 (13.7)	59 (12.7)	68 (14.7)	1.4 (1.0 to 2.1)	0.08	1.3 (0.8 to 2.0)	0.24
Chronic kidney disease							
Stages 3 and 4	168 (18.1)	60 (13.0)	108 (23.3)	2.4 (1.7 to 3.4)	<0.001	2.1 (1.4 to 3.2)	<0.001
Stage 5 and ESRD	93 (10.7)	28 (6.4)	65 (14.9)	2.1 (1.4 to 3.3)	<0.001	1.8 (1.1 to 2.9)	0.01
Chronic congestive heart failure	250 (27.0)	106 (22.9)	144 (31.1)	1.7 (1.3 to 2.4)	<0.001	1.3 (0.9 to 1.8)	0.21
Other cardiovascular disease	353 (40.5)	167 (38.4)	186 (42.7)	1.2 (0.9 to 1.6)	0.18	1.0 (0.7 to 1.3)	0.99
Mental health condition†	209 (22.6)	105 (22.7)	104 (22.5)	1.0 (0.8 to 1.4)	0.89	1.1 (0.8 to 1.6)	0.56
Cancer	80 (8.6)	29 (6.3)	51 (11.0)	3.2 (1.8 to 5.7)	<0.001	4.9 (2.5 to 9.7)	<0.001
HIV	13 (1.4)	5 (1.1)	8 (1.7)	1.6 (0.5 to 5.0)	0.41	2.3 (0.6 to 7.9)	0.20
Charlson Comorbidity Index‡							
0 (low risk)	163 (22.5)	98 (27.8)	65 (17.5)	Ref (1.0)		Ref (1.0)	
1–3 (medium risk)	447 (61.8)	208 (59.1)	239 (64.4)	2.0 (1.4 to 2.8)	<0.001	2.6 (1.6 to 4.2)	<0.001
≥4 (high risk)	113 (15.6)	46 (13.1)	67 (18.1)	3.2 (1.9 to 5.3)	<0.001	4.8 (2.1 to 11.0)	<0.001
Index admission treatment							
Remdesivir	233 (27.7)	130 (34.3)	103 (22.2)	0.5 (0.4 to 0.7)	<0.001	0.5 (0.4 to 0.8)	<0.001
Dexamethasone	419 (49.8)	186 (49.1)	233 (50.3)	0.9 (0.7 to 1.2)	0.43	0.8 (0.6 to 1.1)	0.21
Remdesivir and dexamethasone	216 (25.7)	122 (32.2)	94 (20.3)	0.6 (0.4 to 0.8)	<0.001	0.6 (0.4 to 0.7)	0.002
Required intensive care unit	204 (22.0)	113 (24.4)	91 (19.7)	0.6 (0.5 to 0.9)	0.003	0.5 (0.4 to 0.7)	<0.001
Required mechanical ventilation	100 (11.9)	65 (17.2)	35 (7.6)	0.4 (0.2 to 0.6)	<0.001	0.3 (0.2 to 0.5)	<0.001
Index admission length of stay							
≤7 days	574 (65.9)	294 (67.6)	280 (64.2)	Ref (1.0)		Ref (1.0)	
8–14 days	149 (17.1)	64 (14.7)	85 (19.5)	1.4 (0.9 to 2.0)	0.07	1.3 (0.9 to 1.8)	0.23
>14 days	148 (17.0)	77 (17.7)	71 (16.3)	1.0 (0.7 to 1.4)	0.86	0.8 (0.5 to 1.2)	0.26
Index admission disposition							
Home (self-care)	512 (58.8)	258 (59.3)	254 (58.3)	Ref (1.0)		Ref (1.0)	
Home (with home health services)	133 (15.3)	44 (10.1)	89 (20.4)	2.1 (1.4 to 3.1)	<0.001	1.8 (1.2 to 2.8)	0.007
Long-term acute care hospital	7 (0.8)	3 (0.7)	4 (0.9)	1.4 (0.3 to 6.1)	0.69	0.7 (0.1 to 3.9)	0.71

Continued

Table 2 Continued

	Total population, N=926, n (%)	Non-readmitted, N=463, n (%)	Readmitted, N=463, n (%)	Crude model		Adjusted model*	
				OR (95% CI)	P value	OR (95% CI)	P value
Skilled nursing facility	102 (11.7)	40 (9.2)	62 (14.2)	1.6 (1.0 to 2.4)	0.04	1.3 (0.8 to 2.1)	0.26
Hospice (home or inpatient)	25 (2.9)	19 (4.4)	6 (1.4)	0.3 (0.1 to 0.8)	0.02	0.3 (0.1 to 0.7)	0.008
Transferred to another hospital	27 (3.1)	18 (4.1)	9 (2.1)	0.5 (0.2 to 1.2)	0.11	0.5 (0.2 to 1.2)	0.14
Other§	24 (2.8)	12 (2.8)	12 (2.8)	1.0 (0.4 to 2.3)	0.97	1.0 (0.4 to 2.4)	0.98

Length of stay (of index admission) was not available for VA Medical Center data.
*Adjusted for: gender, obesity, race/ethnicity, hypertension, diabetes, hyperlipidemia, chronic lung disease, chronic kidney disease, congestive heart failure, and mental disease.
†Mental health condition include depression, anxiety, bipolar disorder, and schizophrenia.
‡Charlson Comorbidity Index was not available for the academic safety-net hospital.
§Other was the combination of other rehab, left against medical advice or discontinued care, and other discharge dispositions not included above.
¶Data from all eight hospitals, including six academic health system hospitals, one academic safety-net hospital, and one VA Hospital.
ESRD, end-stage renal disease; VA, Veterans Affairs.

with respect to readmissions by age groups, sex, race, ethnicity, or insurance status.

One novel aspect of this study is the consideration of receipt of targeted inpatient COVID-19 therapeutics during the index hospitalization and their effect on readmissions. Remdesivir and dexamethasone are commonly used in patients hospitalized with severe COVID-19 illness and are the two targeted therapeutics that were available during this study's time period (March 2020–December 2020) in our hospitals. In clinical trials, remdesivir was found to decrease median time to recovery from 15 to 10 days and dexamethasone offered mortality benefit.[36 37] In our study, patients who received treatment during their index hospitalization with remdesivir, with or without dexamethasone, had lower odds of readmission. This is encouraging data and argues for the critical importance of equitable distribution of therapeutic resources during a pandemic. We also found that requiring ICU care or mechanical ventilation during the index hospitalization was associated with lower odds of readmission. Somani *et al* similarly found that readmitted patients were less likely to have required ICU care on index hospitalization.[38] It is possible that patients who require ICU care are more likely to be discharged to skilled nursing facilities, long-term acute care hospitals, and hospice care, and less likely to be readmitted to the hospital.

Most readmitted patients were discharged home (with or without home health services) from their index admission. Patients who discharge home after a COVID-19 admission may face the challenge of medical equipment (eg, home oxygen) and home health nursing needs. These postdischarge services are more easily attained for patients with healthcare insurance or other financial resources. These gaps in postdischarge outpatient management widen disparities perpetuated by SDoH.

Our study confirms previous findings of COVID-19's disproportionate impact on socioeconomically disadvantaged populations. Our analysis of SDoH by race and ethnicity is consistent with the known SDoH impacting patients' outcomes (including hospitalizations and readmissions) with known chronic comorbidities and COVID-19 illness.[39–42] Specifically, disparities in wealth, education, housing, and healthcare access are consistent with the structured systems that disadvantage minority communities.[43–46] Basic needs such as food access and childcare options proved to be disparate as well, which are significant in the recovery of any patient discharged from the hospital.

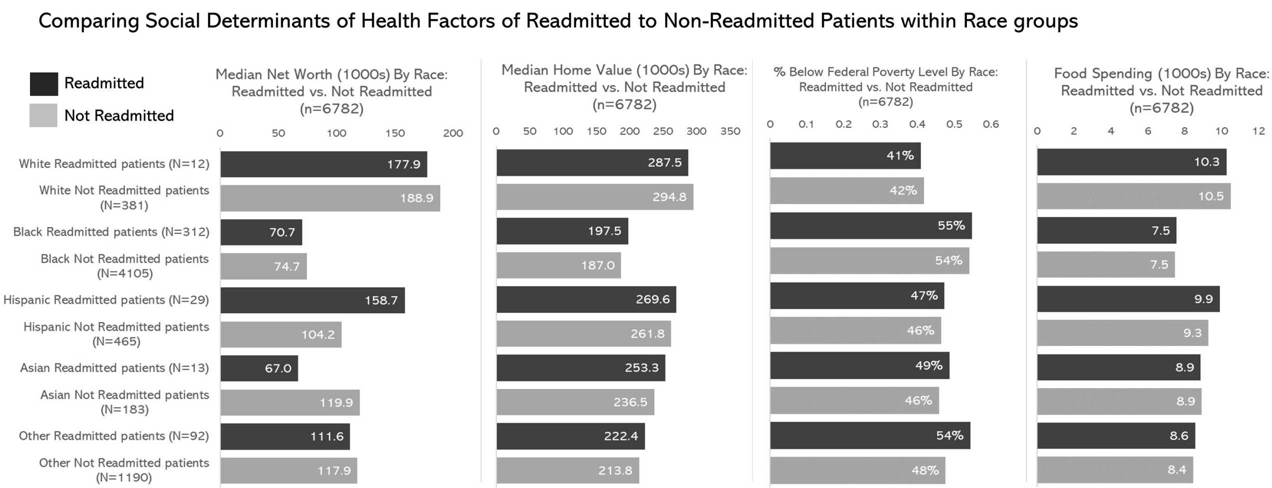

Figure 1 Comparing social determinants of health factors of readmitted to non-readmitted patients within race groups.

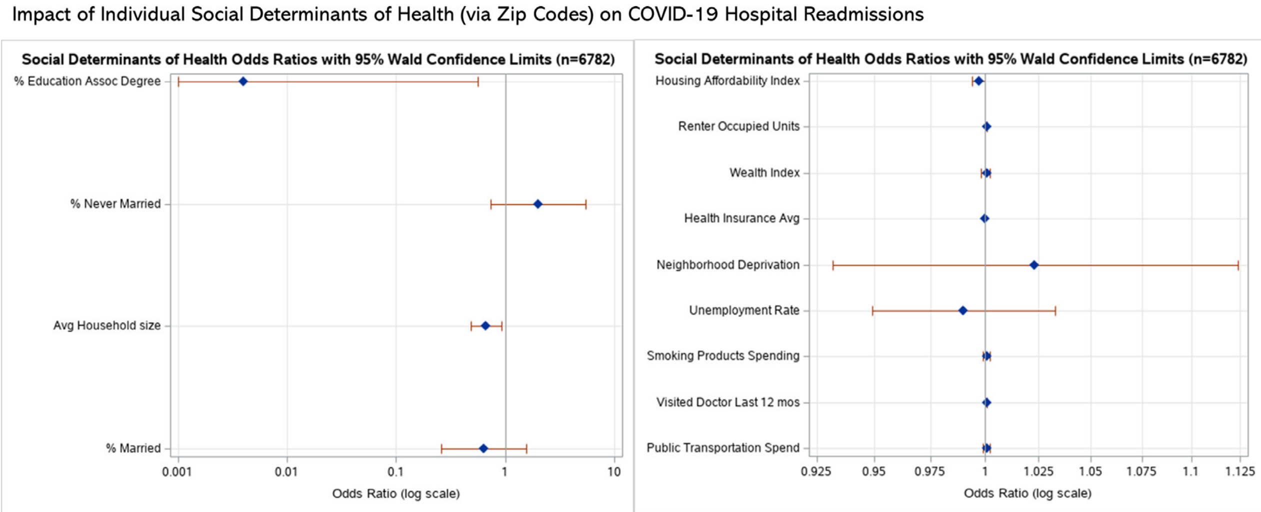

Figure 2 Impact of individual social determinants of health (via ZIP codes) on COVID-19 hospital readmissions. For lower confidence intervals, upper confidence intervals, and p-values, please see online supplemental table 3.

The importance of social support from life partners is also of note: we noted lower odds of readmission in patients who lived in communities with larger households. These disparities reflect differences in the fundamental securities that help minimize stressors to maintain health after hospital discharge.

Limitations

One major limitation to our study is that mortality data for patients discharged after their index admission was not available, and it is not known if patients were readmitted to hospitals outside of the eight hospitals in this cohort. Also, much of the data required manual extraction from the electronic medical records, so the full characteristics of the entire cohort were not available.

The SDoH evaluation in this study was performed using the ESRI Business Analyst Data. This comprehensive demographic and lifestyle database was used to evaluate community-level SDoH based on the readmitted patients' individual ZIP codes. This method is a limitation as it may not reflect the individual patients' SDoH and patients residing within the same ZIP code may cluster within communities and have the same SDoH values for reported variables, thus possibly resulting in less precision. There are also limitations in using this database when the numbers of certain populations (eg, Hispanic readmitted patients) are low. For example, the median net worth of Hispanic readmitted patients was noted to be higher than Hispanic non-readmitted patients, but there were only 29 patients in the former group compared with 465 in the latter. Nevertheless, since many healthcare institutions do not have access to granular SDoH for individual patients, this is a feasible option to understand the community-level SDoH using the patients' ZIP code.

CONCLUSION

We sought to identify predictors that may forecast hospital readmissions and COVID-19 readmission reduction strategy techniques, thus reducing patient-level adverse outcomes and healthcare system financial burdens of COVID-19 readmissions. Although patient demographics (including age, sex, race, and ethnicity) and clinical data (comorbidities and treatments) may be readily available in many healthcare institutions, some may lack the ability to use patient-level SDoH. Our study incorporated community-level SDoH data, via individual patient ZIP code-level data, as a surrogate to patient-level SDoH data. Healthcare systems with limited resources may also consider using more readily available indexes such as the American Community Survey Census data, the pandemic vulnerability index, and area deprivation indexes.[47–49] Future directions include incorporating these clinical predictors and SDoH into prediction models to better identify patients with COVID-19 at increased risk of readmission.[50–52]

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