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ORIGINAL PAPER

Rural-Urban Disparities in Hospital Admissions and Mortality Among Patients with COVID-19: Evidence from South Carolina from 2021 to 2022

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Abstract
Although rural communities have been hard-hit by the COVID-19 pandemic, there is limited evidence on COVID-19 outcomes in rural America using up-to-date data. This study aimed to estimate the associations between hospital admissions and mortality and rurality among COVID-19 positive patients who sought hospital care in South Carolina. We used all-payer hospital claims, COVID-19 testing, and vaccination history data from January 2021 to January 2022 in South Carolina. We included 75,545 hospital encounters within 14 days after positive and confirmatory COVID-19 testing. Associations between hospital admissions and mortality and rurality were estimated using multivariable logistic regressions. About 42% of all encounters resulted in an inpatient hospital admission, while hospital-level mortality was 6.3%. Rural residents accounted for 31.0% of all encounters for COVID-19. After controlling for patient-level, hospital, and regional characteristics, rural residents had higher odds of overall hospital mortality (Adjusted Odds Ratio – AOR = 1.19, 95% Confidence Intervals – CI = 1.04–1.37), both as inpatients (AOR = 1.18, 95% CI = 1.05–1.34) and as outpatients (AOR = 1.63, 95% CI = 1.03–2.59). Sensitivity analyses using encounters with COVID-like illness as the primary diagnosis only and encounters from September 2021 and beyond – a period when the Delta variant was dominant and booster vaccination was available - yielded similar estimates. No significant differences were observed in inpatient hospitalizations (AOR = 1.00, 95% CI = 0.75–1.33) between rural and urban residents. Policymakers should consider community-based public health approaches to mitigate geographic disparities in health outcomes among disadvantaged population subgroups.

Keywords COVID-19 · Outcomes · Mortality · Rurality · Disparities

Introduction

Health inequalities between rural and urban populations have been a long-standing issue in the United States (US), and rural residents face more health challenges compared to their non-rural counterparts. Socioeconomic disadvantages and prevailing difficulties in access to care and utilization of healthcare services, increased disease prevalence and adverse health outcomes, hospital readmissions, and even mortality are disproportionately higher for rural residents compared to suburban and urban residents [1–8]. The distribution of healthcare facilities is also geographically uneven, with only 9% of US hospitals with intensive care unit (ICU) services accounting for 1% of all ICU beds being located in rural areas, while 14% of the population resides in such areas [9].

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The onset of the coronavirus disease 19 (COVID-19) stretched the capacity of the US healthcare system and exacerbated rural and urban disparities in COVID-19-related health outcomes [10–15]. Almost 2,000 health centers, mostly serving low-income and racial/ethnic minority populations, temporarily closed in early 2020, which limited access to primary care services, and thus disproportionately affected access to care for marginalized and disadvantaged populations. Timely access to necessary and comprehensive care became and remained unattainable, particularly over the early stages of the pandemic, and resulted in increased delayed or foregone care for a large share of the population [16–18]. Although the availability of telehealth significantly increased during the pandemic to address gaps in access to care for outpatient medical conditions and to minimize existing disparities, the adoption and use of telemedicine services were lower in more isolated, rural, and socioeconomically vulnerable communities compared to urban settings, further hindering rural residents' access to timely pre-hospital diagnosis [16, 19–21].

Rural and socioeconomically disadvantaged communities have been particularly hard-hit by the pandemic [10–15]. Rural areas had significantly higher COVID-19 related hospitalizations and mortality rates compared to urban areas [10–15]. Evidence across 44 hospitals systems suggests that among COVID-19 infected individuals, rural residents were more likely to die or be transferred to hospice compared to urban residents between January 2020 and June 2021 [11]. Geographic disparities in access to COVID-19 test to treat sites have also been recently documented, with about 60% of rural residents having to travel more than 60 minutes to the nearest site [22]. Vaccination rates against COVID-19 were also lower in rural compared to urban communities, which could further predispose and perpetuate rural-urban differences in adverse outcomes, given the documented effectiveness of vaccines [23–25].

South Carolina is demographically unique compared to national averages, with almost two times higher rates of rural residents [26, 27]. Heavy reliance on private clinics and hospitals for screening and testing for COVID-19 may have exacerbated health disparities for rural residents, despite the strategically located public health clinics to serve rural communities in the state, resulting in increased mortality rates in rural areas, particularly among more socially vulnerable counties [28]. In addition, South Carolina ranked above national averages in COVID-19 death rates and was among the states with the lowest COVID-19 vaccination rates in 2021 [29]. Despite the important contributions of previous studies examining health outcomes by rurality among COVID-19-positive individuals, there is limited evidence regarding the association between COVID-19-related hospitalizations and mortality and rurality using up-to-date statewide hospital data.

The objective of this study was to estimate the variations in hospital admissions and mortality among COVID-19 positive patients by rurality from January 2021 to January 2022 in South Carolina, a period when vaccination against COVID-19 became available in the state. Our findings contribute to the knowledge of rurality as a separate social determinant of health and the need to enhance healthcare system capacity and to improve access to care and health outcomes among disadvantaged subgroups of the population.

Materials and Methods

Study Design and Data Sources

For this study, we used retrospective, secondary data from three sources, the South Carolina Department of Health and Environmental Control (DHEC), the Office of Revenue and Fiscal Affairs (RFA), and the Immunization Information System (IIS). The DHEC COVID-19 testing data were collated from the statewide Case Report Form (CRF; "Human Infection With 2019 Novel Coronavirus Case Report Form") for SARS-CoV. The CRF contains information about laboratory-confirmed and probable cases of COVID-19, including case classification and identification, hospital admission, ICU and death information, case demographics, clinical course, symptoms, medical history, and social history. SC Law (44-29-10) and Regulations (61 – 20) require mandatory reporting of COVID-19 to DHEC [30]. The RFA hospital data included all-payer hospital claims data up to the 13th of January 2022, the most recent data available at the time of the study. This secondary database included sociodemographic and clinical information on all individuals hospitalized within the State. We restricted the data to January 2021 to account for COVID-19 vaccination roll-out in the State. DHEC uses IIS, called the Statewide Immunization Online Network (SIMON), to collect information on COVID-19 vaccine doses at the episode level. SIMON supports the Entire Immunization Partner Community in South Carolina, which includes private clinics, school nurses, local public health agencies, providers, and vendors and enables gathering and analysis of real-time vaccination data in vaccination clinics. SIMON is reliable and representative of all COVID-19 vaccinated individuals in SC.

Cohort Identification

We leveraged a unique and encrypted patient identifier to cross-link all three databases. All in-state residents with any hospital-level encounter (emergency department, outpatient, hospital admission) for COVID-19 were included in the analyses. We identified COVID-19-related visits as encounters within 14 days after laboratory confirmed COVID-19 tests [31]. Since an individual might have multiple hospital encounters (e.g. first seen in the emergency room and then admitted to the hospital) during the study period, we used the patient identifier across the data and created a patient-level dataset. Encounters with recurring dates up to 14 days from the index visit were classified as the same episode. We followed the STROBE guidelines for reporting observational studies [32].

Our study population included adults (≥ 18years of age) who resided and sought hospital care in South Carolina during the study period. Individuals with COVID-19 negative tests, those with COVID-19 positive tests but no hospital encounter, and those with COVID-19 positive tests and encounters beyond 14 days from a laboratory confirmed COVID-19 positive test were excluded similar to previous work [31]. We also excluded individuals who received any vaccine other than the BNT162b2 or mRNA-1273 vaccines (4% received other vaccines), and those with hospital encounters who had received one dose of the vaccine less than 14 days before the encounter or who had a third dose less than seven days before the encounter [31].

Outcomes of Interest and Measurement

Our main outcomes of interest were inpatient hospital admission and mortality among COVID-19 patients seeking care at hospitals in South Carolina [33]. Hospital admission (inpatient) was identified using a dichotomous variable that indicated whether the patient was admitted to the hospital as an inpatient. Mortality was identified from patients' discharge status. The data were de-identified and the study protocol was determined to be not human subjects research by the University of South Carolina Institutional Review Board.

Main Independent Variable and Covariates

Our primary exposure variable was whether a patient resided in a rural or an urban area. We used a dichotomous measure that was available in the data and classified areas as rural or urban based on metropolitan statistical area delineation. We included multiple patient-level, hospital-level, and area of residence-level variables that could be related to hospitalizations and inpatient mortality as controls in our analyses, based on data availability and prior literature. Patient-level sociodemographic and clinical characteristics included sex, race, age, primary payor, COVID-19 vaccination status at the time of the encounter, immunocompromised status, and 7 comorbidities that have been previously associated with COVID-19-related hospitalizations and mortality [34]. Vaccination status was categorized as unvaccinated, partially vaccinated (1 dose of mRNA vaccines), and fully vaccinated (2 doses of mRNA vaccines) and boosted (3 doses of mRNA vaccines). Patients were considered partially or fully vaccinated if they received a second or third dose respectively at minimum 14 days from the hospital encounter [31].

To account for disease severity among hospitalized patients, we included admission to an ICU during hospitalization with or without intubation as an additional variable. Admission to the ICU was identified using two variables that were available in the data which indicated charges for ICU and length of stay in an ICU. Hospitalizations with positive values (> 0) on these variables were deemed as including an ICU admission. Intubation was identified using the Clinical Procedural Terminology (CPT) code for endotracheal intubation (0BH17EZ) across any of the available CPT codes during admission. Hospital- and geographic-level variables included the hospital's teaching status, and patients' distance from the nearest hospital and physician's office. To estimate distances, our geographic unit of analysis was the ZIP Code Tabulation Area (ZCTA). The address of the hospitals with an emergency room was obtained from the 2019 American Hospital Association (AHA) Annual Survey. To calculate the distance of each ZCTA to its nearest hospital and physician office, we first geocoded the addresses into latitude and longitude, and then extracted the centroid (latitude, longitude) of each ZCTA. Then, we calculated the distance from each ZCTA's centroid to all hospitals and physicians' offices and selected the shortest distance from each as our two primary exposure measurements.

Statistical Analysis

We conducted a descriptive analysis of all COVID-19 patients who sought hospital care further stratified by the two outcomes of interest. Differences between cohorts were evaluated using chi-square tests for categorical variables and Mann-Whitney U tests for numeric variables. Multivariable logistic regression models were then used to estimate the associations between inpatient hospital admission and mortality and patients' rural versus urban area of residence, controlling for all covariates mentioned above. We further replicated the regression models and explored inpatient and outpatient mortality and their association with rurality as separate outcomes. Hospital and time (4 periods based on variant prevalence in the state) fixed effects were used to control for unobserved variations and standard errors were clustered at the county level. Sensitivity analyses were conducted by restricting the study period from September 2021 onwards to account for the dominance of the Delta variant and booster vaccination roll-out in the state. Finally, we also conducted additional robustness checks by restricting our study sample to only COVID-19 positive patients with a COVID-like illness documented as the primary diagnosis, similar to previous work [31]. We tested for multicollinearity using the variance inflation factor across all models. Two-tailed tests were used, and statistical significance was considered at $P<.05$. We calculated distances from the nearest hospital and physician's office using ArcGIS, managed the data using SAS version 9.4 (SAS Institute), and performed statistical analyses using Stata version 17.0 (StataCorp).

Results

Characteristics of all Hospital Encounters by COVID-19 Positive Patients in South Carolina Stratified by Hospitalization and Mortality

Table 1 presents descriptive information for all 75,545 COVID-19 hospital encounters overall and stratified by inpatient hospital admission and mortality. Most patients were females (55.5%), White (55.5%), with private insurance (30.5%) or Medicare (33.0%) as the primary payor and resided in urban areas (69.0%). About one-third of all encounters occurred at a teaching hospital (34.0%). The majority of SC patients with COVID-19 were not vaccinated against COVID-19 at the time of the encounter (86.4%). The most prevalent comorbidities were cardiovascular disease (45.6%), diabetes (21.5%), and chronic obstructive pulmonary disease (14.6%).

Overall, 41.8% of encounters resulted in an inpatient hospital admission with a median length of stay of 6 days (Interquartile Range: 4 to 11 days). Around one-quarter of inpatient hospital admissions (25.6%) also involved admissions to an ICU with or without intubation. Overall, hospital-level mortality was 6.3%, with the majority of deaths occurring during hospital admission (inpatient: 97.6%) and 73.1% of deaths also involved admissions to an ICU with or without intubation. Inpatient hospital admissions were relatively similar between rural and urban residents, while overall mortality was about 7.8% higher among rural residents (33.3% versus 30.9%).

Multivariable Regression Estimates

Figure 1 presents the multivariable logistic regression estimates. Compared to residents of urban areas, rural residents had significantly higher odds of overall hospital-level mortality (Adjusted Odds Ratio – AOR = 1.19, 95% Confidence Intervals = 1.04–1.37), after controlling for all covariates. In stratified analyses by setting, the adjusted odds of inpatient mortality (AOR = 1.18, 95% CI = 1.05–1.34) and outpatient mortality (AOR = 1.63, 95% CI = 1.03–2.59) were also higher for rural compared to urban residents. No statistically significant difference was observed between inpatient hospital admission and rurality (AOR = 1.00, 95% CI = 0.75–1.33). Sensitivity analyses by restricting the study period to September 2021 and beyond and by including only COVID-19 positive patients with a COVID-19 like illness as the primary diagnosis yielded similar estimates.

Additional factors positively associated with both outcomes included older age, male sex, congestive heart failure, cardiovascular disease, diabetes, COPD, chronic liver disease, neurological disease, and being immunocompromised (Table 2). In contrast, vaccinated individuals, particularly those with two or three (booster) doses had lower odds of experiencing both outcomes compared to unvaccinated patients. Finally, COVID-19 patients with an indigent or charitable organization as the designated primary payor were less likely to get admitted to a hospital as inpatients (AOR = 0.77, 95% CI = 0.70–0.85) but more likely to die during a hospital encounter (AOR = 1.56, 95% CI = 1.15–2.13) compared to those with private insurance.

Discussion

In our analysis of 75,545 hospital encounters for COVID-19 from January 2021 to January 2022 in South Carolina, we documented that overall hospital-level, inpatient, and outpatient mortality were significantly associated with rurality, after controlling for multiple patient, hospital, and geographic characteristics. Our estimates further indicated that COVID-19 vaccination mitigated the risks for inpatient hospital admission and mortality. Finally, we also found that patients with an indigent or charitable organization as their primary payor were less likely to get admitted to a hospital as inpatients but more likely to die compared to those with private health insurance coverage.

Our study extends the current literature and is in-line with previous work both in South Carolina and nationwide which has documented the differential impact of COVID-19 related mortality on urban and rural areas which are predominantly characterized by lower levels of community resilience [10–15]. Although certain characteristics of rural populations, such as older age and increased prevalence of chronic conditions predispose increased disease severity and mortality when infected with SARS-CoV-2, our adjustment for these factors did not change the finding of increased odds of mortality for rural compared to urban residents. It is possible that already at-risk rural residents presented to hospitals at later stages of the disease, which could explain the increased likelihood of outpatient mortality in

Table 1 Characteristics of COVID-19 related hospital encounters overall and stratified by inpatient hospital admission and mortality in South Carolina from January 2021 to January 2022

		Hospital admission			Mortality during encounter		
	Overall	No	Yes	*P*	No	Yes	*P*
N	75,545	43,942	31,603		70,772	4,773	
%		58.2	41.8		93.7	6.3	
ICU admission with/without intubation (%)	11.2	-	25.6		7.0	73.1	<0.001
Rural (%)				< 0.001			<0.001
No	69.0	68.4	69.8		69.1	66.7	
Yes	31.0	31.6	30.2		30.9	33.3	
Admitted to hospital (%)					38.1	97.6	<0.001
Length of stay - median (IQR)	1 (1–5)	1 (1–1)	6 (4–11)	< 0.001	1 (1–4)	11 (6–18)	<0.001
Age groups (%)				< 0.001			<0.001
18 to 34	22.1	31.9	8.4		23.4	2.1	
35 to 49	23.4	28.2	16.7		24.4	8.3	
50 to 64	25.8	23.1	29.6		25.8	26.7	
65 to 79	20.9	13.1	31.7		19.4	42.3	
80 or more	7.8	3.7	13.6		7.0	20.5	
Sex (%)				< 0.001			<0.001
Male	44.5	40.9	49.4		43.6	56.8	
Female	55.5	59.1	50.6		56.4	43.2	
Race (%)				< 0.001			<0.001
White	55.5	49.5	63.9		54.7	66.8	
Black	38.0	43.3	30.5		38.6	28.6	
Hispanic	3.0	3.4	2.4		3.1	1.7	
Other	3.5	3.8	3.2		3.6	2.8	
Health insurance/Primary Payor (%)				< 0.001			<0.001
Private	30.5	34.0	25.8		31.5	16.1	
Medicare	33.0	20.8	50.0		30.9	65.0	
Medicaid	12.7	16.3	7.7		13.3	4.2	
Uninsured	9.1	11.3	6.2		9.4	5.0	
Indigent/Charitable Organization	9.5	11.7	6.5		9.6	7.5	
Other	5.1	6.0	3.8		5.3	2.2	
Comorbidities (%)							
Congestive Heart Failure	8.2	2.2	16.4	< 0.001	6.9	26.2	<0.001
Cardiovascular Disease	45.6	28.6	69.2	< 0.001	43.7	73.4	<0.001
Diabetes	21.5	11.8	35.1	< 0.001	20.5	37.0	<0.001
COPD	14.6	9.6	21.5	< 0.001	14.1	22.3	<0.001
Chronic Liver Disease	2.4	0.7	4.9	< 0.001	2.0	8.9	<0.001
Neurological Disease	7.7	1.2	16.8	< 0.001	5.9	34.9	<0.001
Asthma	6.5	6.3	6.8	< 0.001	6.7	3.6	<0.001

Table 1 (continued)

	Overall	Hospital admission			Mortality during encounter		
		No	Yes	*P*	No	Yes	*P*
Immunocompromised	5.9	2.2	11.1	< 0.001	5.1	17.9	<0.001
COVID-19 Vaccination status at time of encounter (%)				< 0.001			0.085
Unvaccinated	86.4	86.3	86.7		86.4	87.1	
One dose	3.3	3.1	3.6		3.3	3.7	
Full (2 doses)	9.8	10.1	9.3		9.8	8.8	
Booster (3 doses)	0.5	0.5	0.4		0.5	0.4	

Notes: COPD: Chronic Obstructive Pulmonary Disease; ICU: Intensive Care Unit; IQR: Interquartile Range

particular [35, 36]. We note that we did not find a significant association between inpatient hospital admission and rurality, similar to prior work in South Carolina using 2020 data but unlike other studies using hospital-system or statewide data [11, 14]. This difference could be attributed to the geographic and population-level differences across different states and settings and highlights the importance of state specific analyses to guide local stakeholders and policies using up-to-date evidence.

Our findings indicate that rural residence is an additional social determinant of health and is distinctly associated with adverse health outcomes among patients with COVID-19 in particular. The increased odds of mortality documented in this study among COVID-19 positive patients who resided in rural areas contribute to existing evidence of rurality as a mechanism for downstream disparities in health outcomes and highlight long-standing inequalities in the built environment of healthcare facilities at the community level, particularly for residentially segregated and rural residents, beyond commonly cited unidimensional social determinants of health at the individual level [5, 14, 37–39].

Although decades of research have revealed the stepwise relationship between rurality and health, with increased social needs of rural residents predisposing poorer health outcomes, interest in tackling disparities has heightened due to the unequal impact of the COVID-19 pandemic on marginalized and residentially segregated populations, including the state of South Carolina [14, 38–40]. Remedies to address prevailing social needs related to health should be tailored both at the healthcare system and the social system levels. At the healthcare system level, maintaining and even expanding the scope of practice and use of telemedicine services - desired by both patients and providers - is a first step to bolster access to timely care for certain conditions and mitigate prevailing disparities in healthcare utilization and outcomes [41]. Initiatives and legislation to enhance resources of safety net providers such as Federally Qualified Health Centers, which assist patients with access barriers to care among others, might also be a critical step towards connecting vulnerable populations with needed resources and thus reducing existing geographic disparities.

At the social system, federal and state agencies, policymakers, hospital systems, and health providers, are also uniquely positioned to contribute to narrowing health gaps [41]. Expansion of existing or implementation of new, targeted legislative acts and safety net programs, such as the American Rescue Plan Act, the Earned Income Tax Credit, the expanded Child Tax Credit and food stamps benefits, are critical to alleviate the burden of financial hardships [41]. However, many of these programs are costly short-term remedies to support vulnerable populations and to address long-standing disparities. Instead, directly investing in local

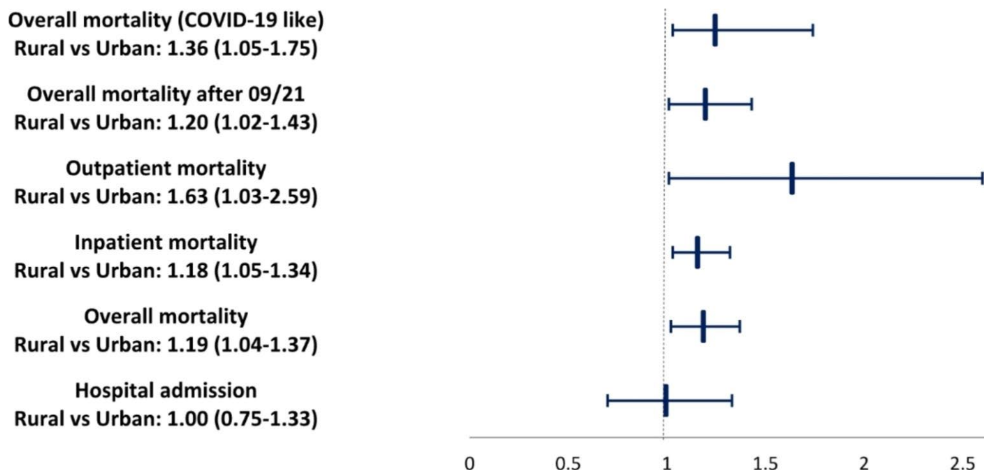

Fig. 1 Forest plot showing the adjusted odds ratios for inpatient hospital admissions and mortality among rural versus urban COVID-19 positive patients in South Carolina

marginalized communities and strengthening the social services sector coupled with multisector coalitions between private and public healthcare providers and community-wide social services that are collectively aligned around a specific location, population or a particular social determinant of health, can allocate resources towards a common goal of improving health outcomes in these communities [40, 41]. The importance of such provisions is further supported by our findings on the association between mortality and having indigent or charitable organizations as primary payors, as well as the protective effect of COVID-19 vaccinations against hospitalizations and mortality. To eliminate social disparities and ultimately promote health equity will require re-allocation and shifts of federal and state budgets from healthcare to underinvested social and educational services. These can improve access to care and population health by transforming the healthcare system from medical-care centered to patient-need centered and recognizing that health inequities are interrelated to social and structural factors [40, 41].

Our study is not without limitations. First, we used data only from one State, and thus our results might not be generalizable to other States due to state-level variability. Despite this, our results are in-line with previous studies that have examined the association between COVID-19 mortality and rurality. Second, it is possible that some encounters were for conditions unrelated to COVID-19, despite the positive COVID-19 test within 14 days from the encounter, which might have resulted in overestimations, due to the identification strategy used. However, we addressed potential selection bias by conducting additional analyses and restricting hospital encounters to only those with a COVID-like illness as the primary diagnosis beyond the positive test [31]. Similarly, the prevalence of patient-level comorbidities might be underestimated if these were not reported in the available diagnostic codes. In addition, we were not able to assess whether rural populations disproportionately delayed seeking care which could contribute to severe outcomes and partially explain differences in mortality. Finally, we were not able to specify certain variables in more detail (e.g. sex, income) due to data availability or include other factors which might predispose COVID-19-related outcomes as controls, such as more detailed clinical information, lab results, and socioeconomic status.

Our findings suggest that mortality among COVID-19 patients was associated with rurality in South Carolina between January 2021 to January 2022. Stakeholders and policymakers should consider enhancing community-based public health and social services' centered approaches to improve health outcomes among disadvantaged subgroups of the population and mitigate long-lasting geographic disparities for underserved Southern populations.

Author Contributions Dr. Giannouchos had full access to all the data in the study and takes responsibility for the accuracy of the data analysis.
Concept and design: Giannouchos, Olatosi.
Acquisition, analysis, or interpretation of the data: Giannouchos, Olatosi, Li, Hung, Li.
Drafting of the manuscript: Giannouchos.
Critical revision of the manuscript for important intellectual content: All authors.
Statistical analyses: Giannouchos.

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Data Availability The University of South Carolina Big Data Health Science Center is prohibited from making individual-level data available publicly due to provisions in the data use agreements with state agencies/data providers, institutional policy, and ethical requirements. To facilitate research, access to such data is made available via approved data access requests. Some University of South Carolina Big Data Health Science Center data is not available externally

Table 2 Multivariable logistic regression estimates of the associations between hospital admission and mortality and COVID-19 positive patients' sociodemographic, contextual and clinical characteristics in South Carolina from January 2021 to January 2022

	Admission		Mortality overall	
	AOR (95% CI)	P value	AOR (95% CI)	P value
Rurality				
Urban	Ref.		Ref.	
Rural	1.00 (0.75–1.33)	0.984	1.19 (1.04–1.37)	0.014
Age groups				
18 to 34	Ref.		Ref.	
35 to 49	1.42 (1.32–1.52)	< 0.001	2.88 (2.28–3.63)	< 0.001
50 to 64	1.97 (1.81–2.15)	< 0.001	6.88 (5.30–8.93)	< 0.001
65 to 79	2.66 (2.41–2.93)	< 0.001	11.55 (8.27–16.15)	< 0.001
80 or more	3.73 (3.25–4.29)	< 0.001	14.71 (10.77–20.10)	< 0.001
Sex				
Male	Ref.		Ref.	
Female	0.80 (0.76–0.84)	< 0.001	0.67 (0.63–0.72)	< 0.001
Race				
White	Ref.		Ref.	
Black	0.69 (0.63–0.76)	< 0.001	0.94 (0.86–1.03)	0.184
Hispanic	1.08 (0.85–1.38)	0.526	0.89 (0.70–1.13)	0.345
Other	1.11 (0.98–1.25)	0.094	1.19 (1.00-1.41)	0.050
Health insurance/Primary Payor				
Private	Ref.		Ref.	
Medicare	0.99 (0.92–1.06)	0.964	1.19 (1.07–1.32)	0.001
Medicaid	0.82 (0.75–0.89)	< 0.001	0.93 (0.71–1.21)	0.587
Uninsured	0.77 (0.64–0.94)	0.010	1.13 (0.92–1.40)	0.250
Indigent/Charitable Organization	0.77 (0.70–0.85)	< 0.001	1.56 (1.15–2.13)	0.005
Other	0.98 (0.89–1.08)	0.686	0.94 (0.73–1.20)	0.618
Comorbidities				
Congestive Heart Failure	2.90 (2.59–3.26)	< 0.001	2.07 (1.87–2.29)	< 0.001
Cardiovascular Disease	2.81 (2.56–3.09)	< 0.001	1.36 (1.19–1.55)	< 0.001
Diabetes	2.04 (1.92–2.18)	< 0.001	1.25 (1.13–1.39)	< 0.001
COPD	2.21 (2.03–2.41)	< 0.001	1.20 (1.10–1.31)	< 0.001
Chronic Liver Disease	4.66 (3.24–6.71)	< 0.001	2.55 (2.08–3.14)	< 0.001
Neurological Disease	9.63 (8.50-10.92)	< 0.001	4.51 (4.06–5.02)	< 0.001
Asthma	0.64 (0.56–0.74)	< 0.001	0.64 (0.52–0.78)	< 0.001
Immunocompromised	3.01 (2.62–3.46)	< 0.001	2.14 (1.92–2.37)	< 0.001
COVID-19 Vaccination status at time of encounter				
Unvaccinated	Ref.		Ref.	
1 dose	0.71 (0.65–0.77)	< 0.001	0.67 (0.57–0.79)	< 0.001
Full	0.41 (0.37–0.44)	< 0.001	0.37 (0.33–0.42)	< 0.001
Booster	0.38 (0.24–0.59)	< 0.001	0.41 (0.26–0.66)	< 0.001
Teaching hospital				
No	Ref.		Ref.	
Yes	1.40 (1.12–1.74)	0.003	1.10 (0.93–1.30)	0.246
Distance from nearest physician office in miles				
Above median	Ref.		Ref.	
>= median	0.94 (0.78–1.13)	0.506	0.94 (0.85–1.03)	0.162
Distance from nearest hospital in miles				
Above median	Ref.		Ref.	
>= median	1.02 (0.90–1.16)	0.753	1.04 (0.97–1.13)	0.275

Notes: COPD: Chronic Obstructive Pulmonary Disease; Ref: Reference; AOR: Adjusted Odds Ratio; CI: Confidence Intervals; The regression models also included hospital and time fixed effects or for re-release due to prohibitions in data use agreements with state agencies or other data providers. Institutional policies stipulate that all external requests for data access require collaboration with a University of South Carolina Big Data Health Science Center researcher. For more information or to make a request, please contact Bankole Olatosi, PhD at Olatosi@mailbox.sc.edu. The underlying analytical codes are available from the authors on request.

Declarations

Ethics Approval Not applicable.

Consent to Participate Not applicable.

Consent for publication Not applicable.

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