Article

Hospitalization and mortality trends among patients with confirmed COVID-19 in the United States, April through August 2020

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Abstract

Background: The United States has experienced high COVID-19 case counts, hospitalizations, and death rates. This retrospective analysis reports changing trends in the demographics and clinical outcomes of hospitalized US COVID-19 patients between April and August 2020.

Design and methods: The Premier Healthcare Database Special Release was used to examine patient demographics of hospitalized COVID-19 patients from all US Census Bureau divisions. Demographics included age, sex, race, and ethnicity. Clinical outcomes included in-hospital mortality, intensive care unit (ICU) admission, and receipt of invasive mechanical ventilation.

Results: Overall, 146,491 hospitalized COVID-19 patients were included (mean [SD] age, 61.0 [18.4] years; 51.7% male; 29.6% White non-Hispanic). Monthly total hospitalizations decreased from 44,854 in April to 18,533 in August; ICU admissions increased from 19.8% to 23.6%, and ventilator use and inpatient mortality decreased from 18.6% to 14.5% and 21.0% to 11.4%, respectively. Inpatient mortality was highest in the Middle Atlantic division (20.3%), followed by the New England (19.0%), East North Central (14.2%), and Mountain (13.7%) divisions. Black non-Hispanic patients were overrepresented among hospitalizations (19.0%); this group comprises 12.2% of the US population. Patients aged <65 years made up 53% of hospitalizations and had lower inpatient mortality than those aged ≥65 years.

Conclusions: Hospitalizations, ventilator use, and mortality decreased, while ICU admission rates increased from April to August 2020. Older individuals and Black non-Hispanics were found to be at elevated risk of severe outcomes. These trends could inform ongoing patient care and US public health policies to limit the further spread of SARS-CoV-2.

Introduction

Severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) and the associated disease (COVID-19) emerged as a global threat to public health in 2020.[1] On March 11, 2020, the World Health Organization (WHO) declared the COVID-19 outbreak a pandemic, owing to the rapidly increasing number of global cases and deaths.[1] Globally, mitigation strategies, including movement restrictions, face coverings, social distancing, and temporary closures of nonessential businesses, successfully reduced widespread transmission of SARS-CoV-2;[2,3] however, many countries are now seeing a resurgence in the spread of SARS-CoV-2 following the relaxation of stay-at-home orders and the reopening of economies.[3,4] As of March 4, 2021, more than 114.8 million confirmed cases of COVID-19 and more than 2.5 million attributed deaths have been reported worldwide.[5]

The United States in particular has faced a heavy COVID-19 case count and death toll; as of March 4, 2021, there have been more than 28.5 million cases, resulting in over 500,000 deaths.[6] The overall number and rate of hospitalizations remains an important indicator of COVID-19 burden and severity; recent national surveillance data show rising hospitalization rates and report that certain populations face greater risk of hospitalization than others.[7] Data from ongoing surveillance studies and retrospective analyses have consistently demonstrated that male sex, older age, and underlying comorbidities are substantial risk factors for poor clinical outcomes following COVID-19 diagnosis.[7-10] Additionally, certain racial and ethnic groups in the United States are disproportionately affected by COVID-19 and experience poor outcomes,[10,11] potentially due to disparities in education, income, and healthcare access and utilization.[12]

In the absence of universal federal guidelines, strategies to limit the spread of SARS-CoV-2 in the United States have been left to the jurisdiction of individual states and territories.[13] Between March 1 and May 31, 2020, 42 states and territories issued mandatory stay-at-home orders of varying duration and stringency.[13] Consequently, the number of COVID-19 cases and deaths have varied considerably among US geographic regions.[6]

Significance for public health

The impact of the COVID-19 pandemic on public health in the United States has been significant. Due to the ever-evolving nature of the pandemic, healthcare workers and public health experts require a thorough understanding of the clinical outcomes of hospitalized COVID-19 patients. This study found that despite decreases in overall mortality rates as the pandemic continues, certain demographic groups, including the elderly and Black non-Hispanics remain disproportionately affected. Such information could inform ongoing care of COVID-19 patients, as well as shape public health policies to address health disparities to limit the ongoing spread of SARS-CoV-2.

Further, certain areas that had successfully limited the spread of SARS-CoV-2 are now seeing increases in case counts, likely fueled by the reopening of many states' economies.[3,6,13]

This retrospective analysis reports changing trends in the demographics and clinical outcomes of hospitalized COVID-19 patients in various US Census divisions between April and August 2020. Such information is crucial to inform regional healthcare providers and health officials who are involved in efforts to address the ongoing COVID-19 pandemic.

Methods

Study population

This retrospective observational study used the Premier Healthcare Database Special Release (PHD-SR), which was specifically developed for COVID-19 research.[14] The PHD-SR is a hospital-based, service-level, all-payer database containing information on inpatient discharges and hospital-based outpatient visits from nonprofit, nongovernmental community and teaching hospitals and health systems from urban and rural areas of the United States. The PHD-SR contains information from a subset of >800

facilities that submit data on a weekly, biweekly, or monthly basis with an approximate data lag time of 1 to 3 weeks from date of discharge. Institutional review board approval was not required for this study because the PHD-SR is a statistically de-identified data set and is Health Insurance Portability and Accountability Act (HIPAA) compliant.

Patients with laboratory-confirmed infection of SARS-CoV-2, regardless of clinical signs or symptoms, are assigned the International Classification of Diseases, Tenth Revision, Clinical Modification (ICD-10-CM) diagnosis code U07.1.[15,16] For this study, patients admitted in January 2020 or later with a discharge diagnosis of ICD-10-CM U07.1 were identified in the PHD-SR and included in the analysis. For patients with multiple encounters for COVID-19 during the study time frame, the first encounter was included in this study. The ICD-10-CM code U07.1 officially came into effect on April 1, 2020,[17] and this study included records through August 2020; therefore, only patients discharged between April 1 and August 31 (inclusive of these dates) are included. Demographic variables of interest included age, sex, race (White, Black, Other [Asian, American Indian and Alaska Native, Native Hawaiian, and other Pacific Islander, and those reporting more than 2 races], or unknown), ethnicity (Hispanic, non-Hispanic, or unknown), and census division. Race and ethnicity designations in
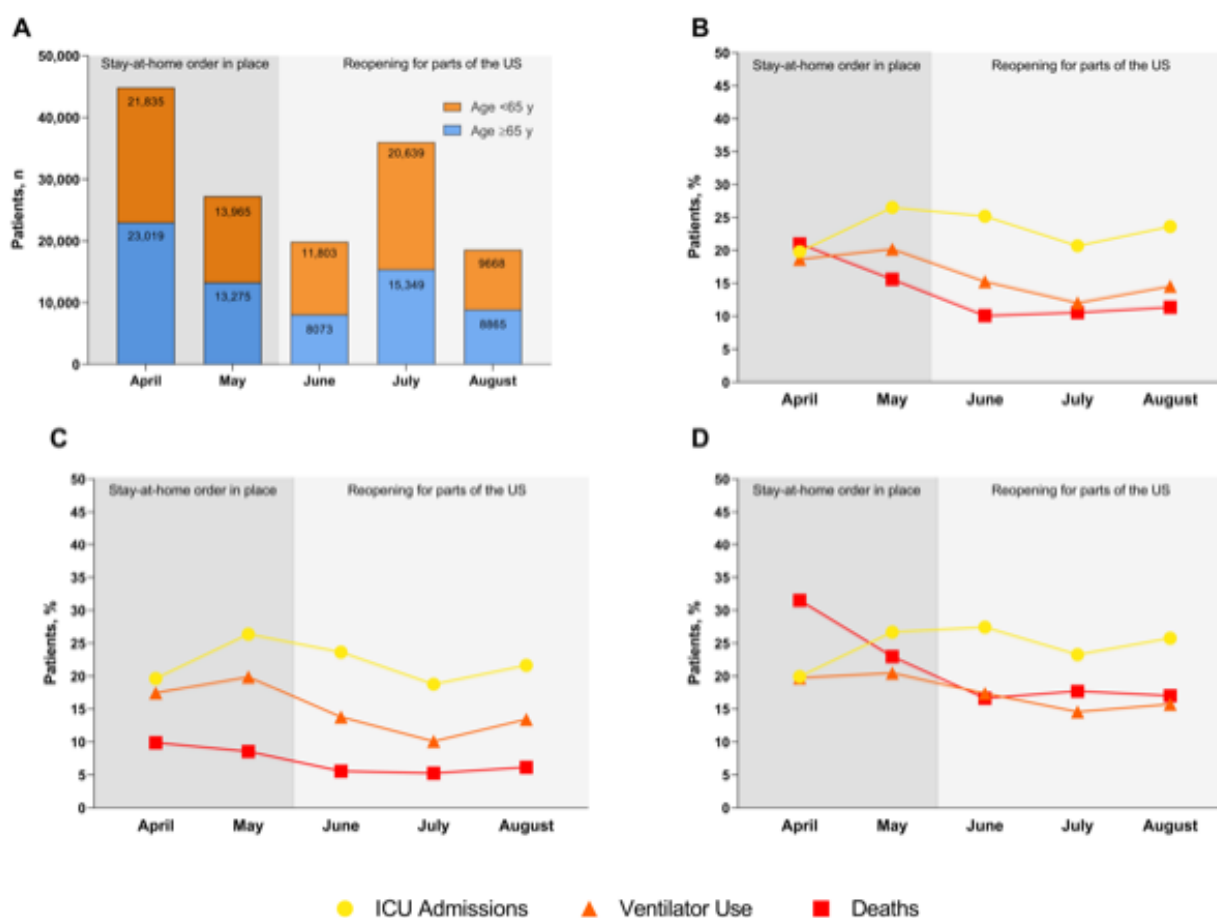

Figure 1. Total hospitalizations (A), clinical outcomes for patients hospitalized with COVID-19 by discharge month for all patients (B), <65 years age group (C), and ≥65 years age group (D). ICU, intensive care unit.

PHD-SR are patient self-reported and follow the Centers for Medicaid and Medicare Services 1450/UB-04 uniform billing form. "Race/Ethnicity" combined categories were generated by combining both race and ethnicity fields; these included Asian Hispanic, Asian non-Hispanic, Black Hispanic, Black non-Hispanic, White Hispanic, White non-Hispanic, Other Hispanic, Other non-Hispanic, and Unknown, which includes patients with missing race and/or ethnicity information. "Race/Ethnicity" is "unknown" if a patient declines to self-report race and ethnicity information or if this information is not collected at hospital admission. Additional hospitalization and patient characteristics of interest included length of hospitalization, intensive care unit (ICU) admission, length of stay in ICU, ventilator use, and death during hospitalization.

Outcomes

The primary outcomes of interest were overall in-hospital mortality, admission to the ICU, and receipt of invasive mechanical ventilation. Outcomes were defined using a combination of ICD-10-CM, Current Procedural Terminology, and discharge status codes, as well as standard hospital service charge descriptions. Patient demographics were examined across each of the primary outcomes to evaluate the role of demographic factors on the risk of hospitalization and subsequent in-hospital clinical outcomes. Data were analyzed by month to determine COVID-19 outcomes among hospitalized patients during the mandatory stay-at-home order period (from study start in April 2020 through May 31, 2020)[13] and during the period when parts of the country were reopening (June through August 2020).

Statistical analysis

Descriptive statistical analyses were performed to calculate the proportion of confirmed COVID-19 hospitalizations that required treatment in the ICU or invasive mechanical ventilation, as well as COVID-19 hospitalizations that resulted in in-hospital mortality. Binary and categorical variables were summarized as counts and proportions of the total study population and by subgroups when appropriate. Continuous variables were summarized as means and standard deviations (SD).
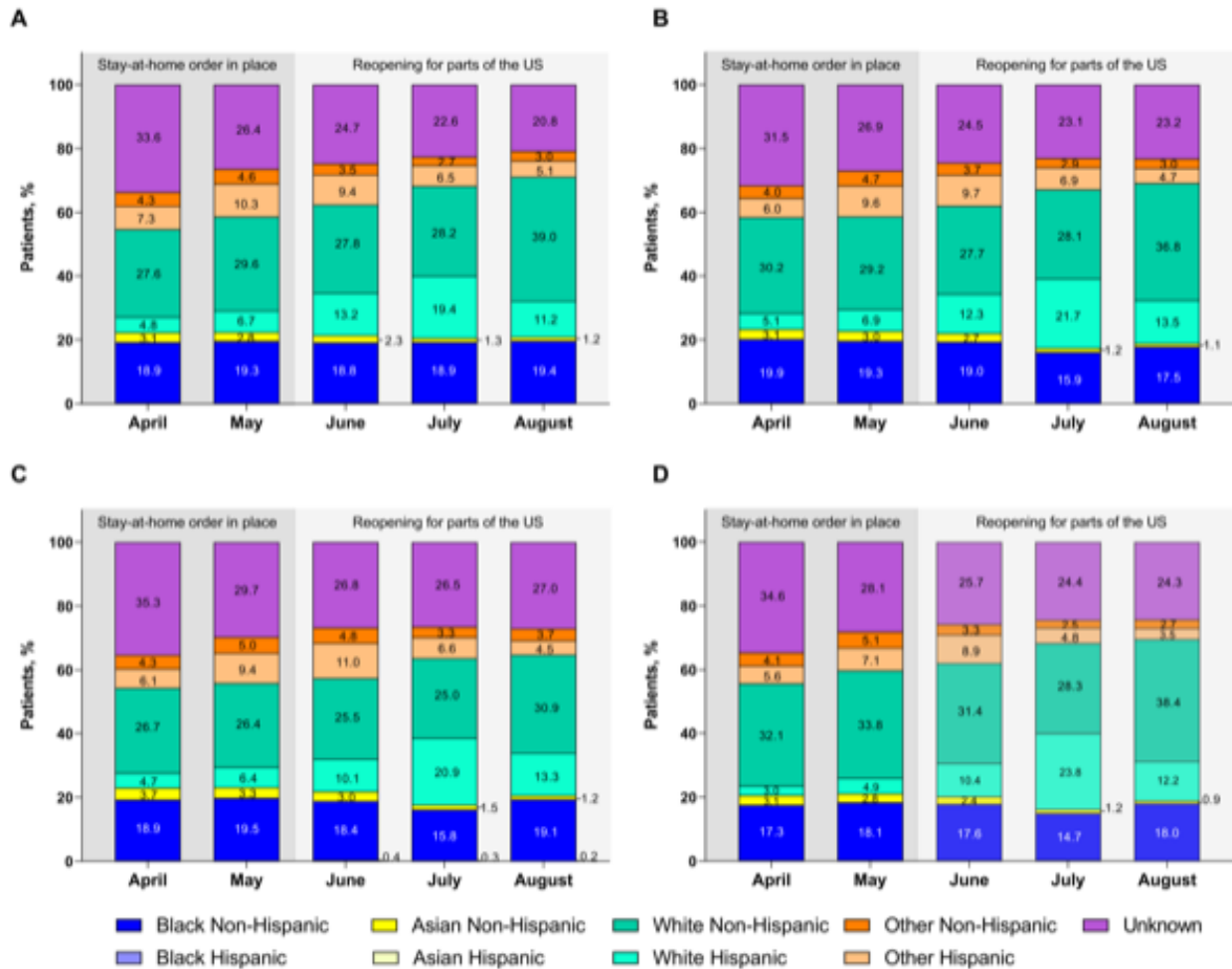

Figure 2. Distribution of race and ethnicity among US patients hospitalized with COVID-19 by discharge month for hospitalizations (A), ICU admissions (B), ventilator use (C), and mortality (D). COVID-19, coronavirus disease-19; ICU, intensive care unit; Other, native Hawaiian and other Pacific Islander, American Indian and Alaska native, and some other races; Unknown, all patients missing information on race and/or ethnicity.

Results

A total of 146,491 patients hospitalized in the United States between April and August 2020 were included in this analysis (mean [SD] age, 61.0 [18.4] years; 51.7% male; 29.6% White non-Hispanic; Table 1). Most patients were from the Middle Atlantic census division (27.2%), followed by South Atlantic (24.3%), East North Central (11.8%), and West South Central (11.7%) census divisions.[18]

Outcomes

Among all patients admitted between April and August 2020, the mean (SD) length of hospitalization was 9.0 (9.6) days, 22.5% were admitted to the ICU, 16.3% received mechanical ventilation, and the overall mortality rate was 14.7% (Table 1). Total COVID-19 hospitalizations decreased from 44,854 in April to 18,533 in August, albeit with a spike in July (n=35,988; Figure 1A). While hospitalizations decreased, the percentage of COVID-19 hospitalized patients admitted to the ICU increased from April to May and June (from 19.8% to 26.5% and 25.2%, respectively), and fell to 20.7% in July before rising again in August to 23.6% (Figure 1B). Despite higher rates of ICU admission, both ventilator use and inpatient mortality decreased from 18.6% to 14.5% and from 21.0% to 11.4%, respectively, between April and August (Figure 1B).

Outcomes by age

The mean (SD) age of patients hospitalized during the study period was 61.0 (18.4) years (Table 1). Overall, 53.2% of hospitalized patients were aged <65 years, ranging from 48.7% in April to 59.4% in June. Within age groups (<65 *vs* ≥65 years), similar percentages of hospitalizations, ICU admissions, and ventilator use were reported in April (Figure 1 C,D). As with the overall population, there was an increase in the percentage of patients admitted to the ICU in both age groups from April to May and June. Ventilator use and deaths in the <65-year age group generally decreased over the same time frame.

During the study period, patients aged ≥65 years consistently had higher inpatient mortality compared with those aged <65 years (Figure 1 C,D). Monthly trends show that inpatient mortality decreased steadily in patients aged <65 years from 9.9% in April to 5.3% in July, after which there was a slight increase in August (6.2%). In comparison, there was a sharp decrease in inpatient mortality among patients aged ≥65 years, from 31.5% in April to 16.6% in June, after which inpatient mortality remained relatively stable in this age group.

Outcomes by race, ethnicity, and geographic division

Overall, non-Hispanic patients accounted for the majority of hospitalizations during the study period (56.2%), followed by Hispanic patients (21.9%) and patients with unknown ethnicity (21.8%). White non-Hispanic patients accounted for the largest share of hospitalizations (29.6%), followed by Black non-Hispanics (19.0%; Table 1). Black non-Hispanic patients were overrepresented for hospitalizations, as they account for 12.2% of the total US population. Similarly, monthly trends showed that even though White non-Hispanics accounted for the largest proportion of hospitalized patients, ICU admission, ventilator use, and deaths, Black non-Hispanics were the most overrepresented demographic group for all 4 categories relative to their national repre-
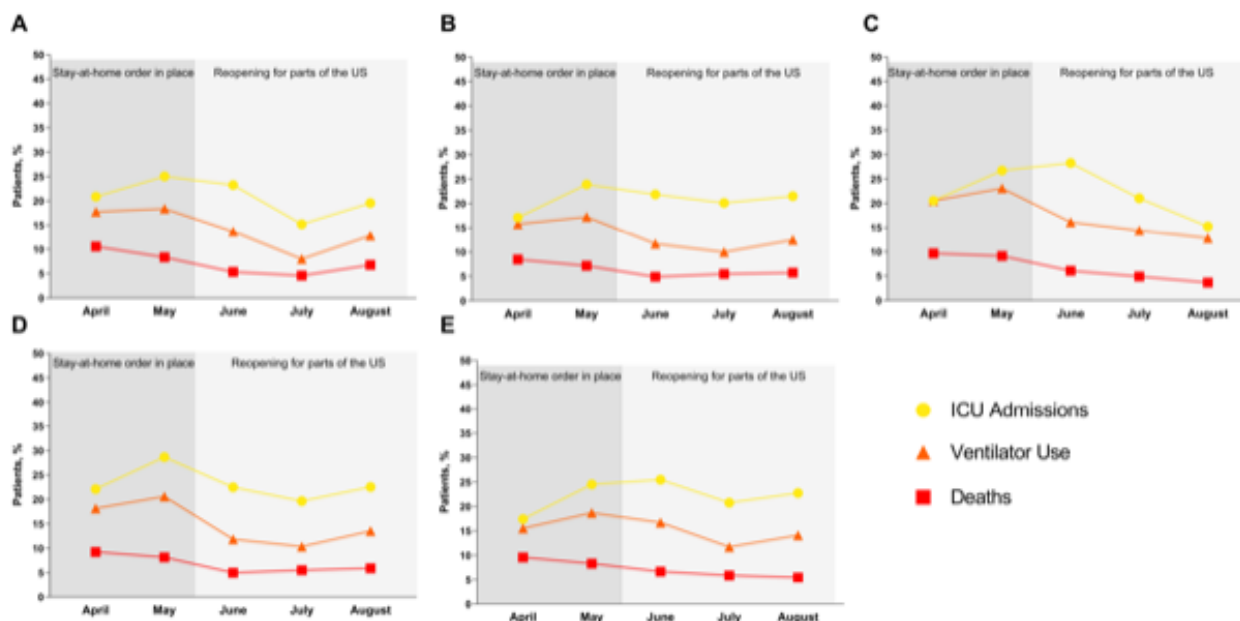

Figure 3. Clinical outcomes of us patients aged <65 years hospitalized with COVID-19 stratified by race or ethnicity for Black (A), Hispanic (B), Asian (C), White (D), and other races (E). Panels A, C, D, and E are by race, regardless of ethnicity; panel B is by ethnicity regardless of race. ICU, intensive care unit; Other, native Hawaiian and other Pacific Islander, American Indian and Alaska native, and some other races.

sentation (Figure 2). The overrepresentation of Black non-Hispanics for hospitalization was also observed on the individual census division level, for example, comprising up to 14.7% and 30.3% of the monthly hospitalizations in West North Central and East North Central divisions, respectively (Supplementary Table 1).

The mean (SD) length of hospitalization during the study period was similar among the census divisions, ranging from 8.0 (8.2) to 10.0 (10.9) days (Supplementary Table 1). Among the 9 census divisions, Middle Atlantic and New England saw sharp increases in the mean length of hospitalization between April and June, followed by declines in July and August; similar trends for mean length of ICU stay and the percentage of patients receiving mechanical ventilation were also observed for the Middle Atlantic and New England census divisions. The Middle Atlantic census division experienced the greatest overall inpatient mortality (20.3%) during the study period, followed by New England (19.0%), East North Central (14.2%), and Mountain (13.7%) census divisions (Supplementary Table 1). There were consistent reductions in monthly inpatient mortality for all census divisions between April and June, after which there was an increase in July and August for all census divisions except East North Central and Middle Atlantic, where inpatient mortality remained steady for July and August.

When race and geography were jointly assessed, Black non-Hispanics were disproportionately at risk of hospitalization during each month of the study period in several census divisions including the East North Central, East South Central, Middle Atlantic, South Atlantic, West North Central, and West South Central divisions (Supplementary Table 1). Further analysis of clinical outcomes across race and ethnicity categories revealed that for all races and ethnicities, adults aged <65 years were at lower risk of ICU admission, ventilator use, and death (Figure 3) compared with individuals aged ≥65 years (Figure 4). Within each age group, no

discernible differences in clinical outcomes were observed between race and ethnicity categories (Figures 3 and 4).

Discussion

To our knowledge, this is one of the largest studies to date describing hospitalized COVID-19 patients in the United States. A total of 146,491 patients from all 9 US census divisions were included in this analysis of monthly patient data from April to August 2020. The data from this study show a general trend of decreasing total hospitalizations and inpatient mortality in the United States during the study period. However, 2 peaks in overall hospitalizations were observed, the first occurring in April and the second in July. These data are consistent with those reported by the US Centers for Disease Control and Prevention (CDC), which reported peak weekly hospitalization rates for all ages in mid-April, followed by a second peak in mid-July.[19] In mid-March 2020, states began issuing stay-at-home orders in anticipation of the first surge in cases and the second peak may have resulted from the lifting of these orders.[13]

Inpatient mortality reported early in the study in April (21.0%) is in line with several other studies from the United States that reported inpatient mortality rates ranging from 10% to 50% at the time.[20-23] In this study, inpatient mortality rates decreased to 11.4% by August, consistent with the 6.6% to 10.7% mortality rates reported by the CDC for the last 2 weeks of August 2020.[19] Declining case fatality rates have also been reported in other countries, even in the face of increasing hospitalization rates.[24,25] Potential reasons for improvements in clinical outcomes could be a combination of improved and timely diagnosis, changing practices regarding ventilator use, better pharmacologic treatments such as systemic corticosteroids and remdesivir, better community
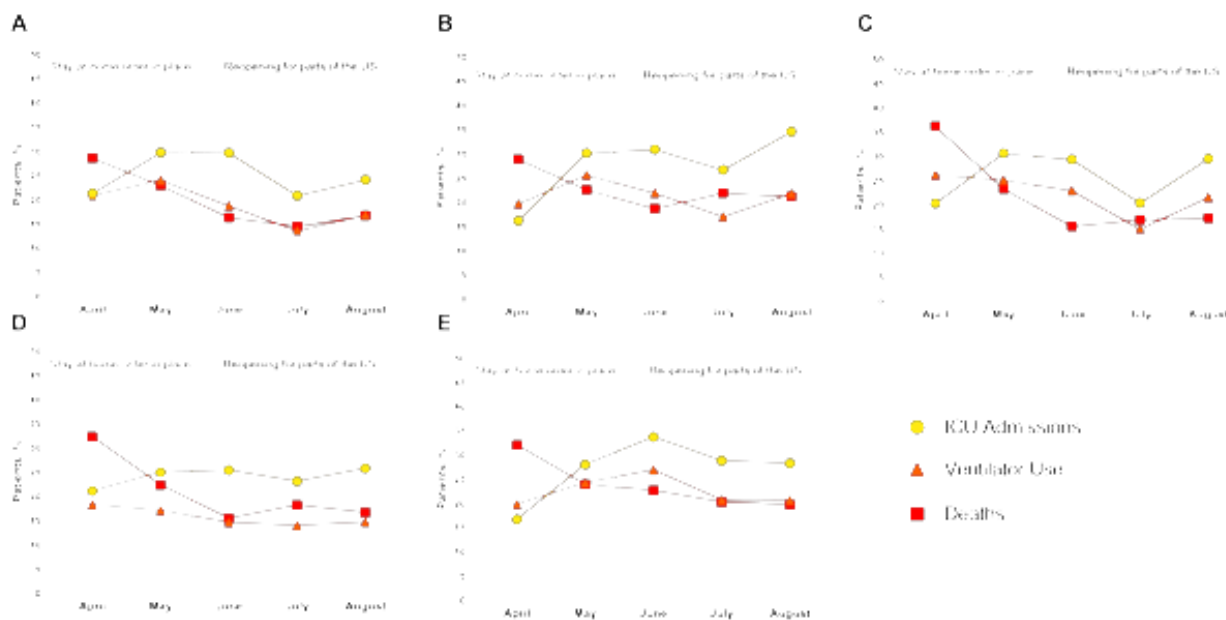

Figure 4. Clinical outcomes of US patients aged ≥65 years hospitalized with COVID-19 stratified by race or ethnicity for Black (A), Hispanic (B), Asian (C), White (D), and other races (E). Panels A, C, D, and E are by race, regardless of ethnicity; panel B is by ethnicity regardless of race. ICU, intensive care unit; Other, native Hawaiian and other Pacific Islander, American Indian and Alaska native, and some other races.

awareness of the disease, and lower viral load exposure due to mask wearing and adherence to social distancing guidelines.[2,3,26-29]

In this study, a change in the age distribution of hospitalized COVID-19 patients was observed over time, with a trend toward an increasing proportion of hospitalized patients who were in the group aged <65 years. Similarly, the CDC has reported shifts in the age distribution of patients diagnosed with COVID-19 in the United States, with the largest increases reported between May and July in individuals aged <30 years.[30] Additionally, the WHO reported that between February and July 2020, the proportion of global cases in patients aged 0 to 4 years, 5 to 24 years, and 25 to 64 years increased by 3- to 7-fold depending on the age group.[31] These shifts could be a consequence of the easing of social distanc-ing and public health measures, which might lead to increased transmission among the younger age groups.[31] Additionally, a sur-vey by the CDC observed that individuals aged 18 to 29 years were less likely to engage in thorough COVID-19 mitigation behaviors, including mask wearing, maintaining appropriate social distance, and avoiding public and crowded places compared with individu-als aged ≥60 years[32]; such behaviors could further contribute to greater rates of infection among younger individuals. In this study, despite individuals aged <65 years making up 53% of COVID-19 hospitalizations overall, inpatient mortality was still consistently lower than for patients aged ≥65 years, consistent with observa-tions from other studies throughout the pandemic.[33,34] Additionally, inpatient mortality for patients aged ≥65 years also

Table 1. Overall characteristics of patients hospitalized with COVID-19, April-August 2020.

		Total N=146,491
Mean (SD) age, y		61.0 (18.4)
Age group, n (%)		
<65 y		77,910 (53.2)
≥65 y		68,581 (46.8)
Sex, n (%)		
Male		75,771 (51.7)
Female		70,602 (48.2)
Unknown		118 (0.1)
Race, n (%)		
Asian		3943 (2.7)
Black		33,630 (23.0)
Other*		25,176 (17.2)
White		74,394 (50.8)
Unknown#		9348 (6.4)
Ethnicity, n (%)		
Hispanic		32,138 (21.9)
Unknown#		31,995 (21.8)
Race and ethnicity, n (%)	**US population estimate, %°**	
Asian Hispanic	0.1	58 (0)
Asian non-Hispanic	4.7	3278 (2.2)
Black Hispanic	0.4	489 (0.3)
Black non-Hispanic	12.2	27,839 (19.0)
White Hispanic	8.7	15,688 (10.7)
White non-Hispanic	63.8	43,351 (29.6)
Hispanic*	6.2	11,205 (7.7)
Other non-Hispanic*	1.1	5418 (3.7)
Unknown#	-	39,165 (26.7)
US Census Division, n (%)		
East North Central		17,209 (11.8)
East South Central		8722 (6.0)
Middle Atlantic		39,864 (27.2)
Mountain		10,137 (7.0)
New England		3850 (2.6)
Pacific		8363 (5.7)
South Atlantic		35,635 (24.3)
West North Central		5597 (3.8)
West South Central		17,114 (11.7)
Length of hospitalization, days		
Mean (SD)		9.0 (9.6)
Median (1st–3rd quartiles)		6 (3–11)
ICU admission, n (%)		32,950 (22.5)
Mean (SD) length of ICU stay, days		9.0 (10.3)
Median (1st–3rd quartiles) length of ICU stay, days		6 (2–13)
Ventilator use, n (%)		23,897 (16.3)
Deaths, n (%)		21,563 (14.7)

COVID-19, coronavirus disease-19; ICU, intensive care unit; *includes native Hawaiian and Other Pacific Islander, American Indian and Alaska native, and some other race; #includes all patients missing information on race and/or ethnicity; °based on 2018 American Community Survey 1-year estimates available at census.gov.

decreased over time, potentially attributable to improvements in diagnosis, patient management, and treatment.[26-28]

Several studies have consistently reported that racial and ethnic minorities are disproportionately affected by COVID-19.[10,11,35,36] In this study, Black non-Hispanics were overrepresented relative to their national population in several census divisions, occasionally by over 2-fold. Most prominently, Black non-Hispanics make up only 6.4% of the population in the West North Central and 11.9% in the East North Central divisions[37] yet comprised up to 14.7% and 30.3% of the monthly hospitalizations in these divisions, respectively. Of note, this study did not account for comorbidities and socioeconomic status. These characteristics will be important to address in future work because longstanding systemic health and social inequities are known to put racial and ethnic minorities at increased risk of illness.[12] Additionally, mandatory restrictions enacted during the pandemic could have put such patients at further disadvantage of obtaining timely care, thus putting them at further risk for COVID-19 and at risk of higher burden of disease and poor outcomes.[12]

Limitations

This study should be considered in light of several limitations inherent to analyses using administrative data. The PHD-SR contains patient-level data extracted from hospital discharge billing files and, as such, longitudinal baseline and follow-up data (i.e., preadmission and post-discharge) are not available. Additionally, the PHD-SR includes patient self-reported data and could therefore be subject to reporting error.

Conclusions

This descriptive analysis provides important information relating to US COVID-19 hospitalization and mortality trends from April to August 2020, including the time periods in which many states implemented and then lifted stay-at-home orders. The study demonstrated that hospitalizations, ventilator use, and mortality have decreased over the course of the study period, while ICU admission rates have remained fairly constant. Other themes, including worse clinical outcomes for older patients and the disproportionate hospitalization among Black non-Hispanics, remained consistent throughout the study period. The results of this study are important for informing ongoing patient care, as well as public health policies, to address health disparities of COVID-19 in the United States.

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