Open Forum Infectious Diseases

MAJOR ARTICLE

Relative Risks of COVID-19–Associated Hospitalizations and Clinical Outcomes by Age and Race/Ethnicity—March 2020–March 2021

Catherine H. Bozio,[1,2] Kristen Butterfield,[3] Stephanie A. Irving,[4] Gabriela Vazquez-Benitez,[5] Toan C. Ong,[6] Kai Zheng,[7] Sarah W. Ball,[3] Allison L. Naleway,[4] Michelle Barron,[6] and Carrie Reed[1,2]

[1]COVID-19 Emergency Response, Centers for Disease Control and Prevention, Atlanta, GA, USA, [2]Influenza Division, National Center for Immunization and Respiratory Diseases, Centers for Disease Control and Prevention, Atlanta, Georgia, USA, [3]Westat, Rockville, Maryland, USA, [4]Center for Health Research, Kaiser Permanente Northwest, Portland, Oregon, USA, [5]HealthPartners Institute, Bloomington, Minnesota, USA, [6]Department of Medicine, University of Colorado, Anschutz Medical Campus, Aurora, Colorado, USA, and [7]University of California, Irvine, California, USA

Background. Limited data exist on population-based risks and risk ratios (RRs) of coronavirus disease 2019 (COVID-19)–associated hospitalizations and clinical outcomes stratified by age and race/ethnicity.

Methods. Using data from electronic health records and claims from 4 US health systems for the period March 2020–March 2021, we calculated risk and RR by age and race/ethnicity for COVID-19–associated hospitalizations and clinical outcomes among adults (≥18 years). COVID-19–associated hospitalizations were defined based on COVID-19 discharge codes or a positive severe acute respiratory syndrome coronavirus 2 result. Proportions of acute exacerbations of underlying conditions were estimated among hospitalized patients with select underlying conditions, stratified by age and race/ethnicity.

Results. Among 2.6 million adults included in the patient cohort, 6879 had COVID-19–associated hospitalizations during March 2020–March 2021 (risk: 264 per 100 000 population). Compared with younger, non-Hispanic White adults, non-Hispanic Black and Hispanic adults aged ≥65 years had the highest hospitalization risk ratios (RR, 8.6; 95% CI, 7.6–9.9; and RR, 9.3; 95% CI, 8.5–10.3, respectively). Among hospitalized adults with COVID-19 and renal disease or cardiovascular disease, the highest proportion of acute renal failure (55.5%) or congestive heart failure (43.9%) occurred in older, non-Hispanic Black patients. Among hospitalized adults with chronic lung disease or asthma, the highest proportion of respiratory failure (62.9%) or asthma exacerbation (66.7%) occurred in older, Hispanic patients.

Conclusions. During the first year of the US COVID-19 pandemic in this cohort, older non-Hispanic Black and Hispanic adults had the highest relative risks of COVID-19–associated hospitalization and adverse outcomes and, among those with select underlying conditions, the highest occurrences of acute exacerbations of underlying conditions.

Keywords. COVID-19; adults; hospitalization; race/ethnicity.

The severity of coronavirus disease 2019 (COVID-19) disease and associated clinical outcomes has been described among hospitalized patients [1, 2]. In particular, older adults and racial/ethnic minorities have been disproportionately affected by COVID-19 [1–5], though risks of COVID-19–associated hospitalizations or clinical outcomes, especially further stratified by both age and race/ethnicity, are limited [6, 7], but it may be helpful to understand how each factor influences the risk of COVID-19–associated outcomes. Further, persons with underlying conditions have also been disproportionately affected by COVID-19 [1, 2, 8], so it is important to also understand the occurrence of acute exacerbations of select conditions among patients hospitalized with COVID-19, particularly across age and race/ethnicity.

The Centers for Disease Control and Prevention, in collaboration with 4 US health care systems with integrated medical and laboratory records, established the VISION Network to understand the burden of COVID-19 disease, particularly among disproportionately affected persons, and later expanded to include additional sites to evaluate COVID-19 vaccine effectiveness. Using these data, we sought to estimate population-based risks and risk ratios stratified by age and race/ethnicity of COVID-19–associated hospitalizations and clinical outcomes.

METHODS

Study Population and Design

The VISION network was comprised of 4 health systems: HealthPartners (HP; Minnesota and Wisconsin), Kaiser Permanente Northwest (KPNW; Oregon and Washington), University of Colorado Health, and University of California Health. Data on patient characteristics, hospital encounters,

Received 01 April 2022; editorial decision 22 July 2022; accepted 29 July 2022

Correspondence: C. Bozio, Centers for Disease Control and Prevention, 1600 Clifton Rd NE, MS H24-7, Atlanta, GA 30333 (ise7@cdc.gov).

Open Forum Infectious Diseases®

https://doi.org/10.1093/ofid/ofac376

and respiratory virus testing were extracted from electronic health records and claims across 87 hospitals. A retrospective patient cohort was constructed to include persons aged ≥18 years who had ≥1 ambulatory visit within the health system in the 12 months before September 1, 2019 (hereafter referred to as the look-back period) to reflect health care–seeking behavior before the COVID-19 pandemic began. In addition, for KPNW and HP, persons were also required to have active membership in or insurance with the integrated health care system for the period of 12 months before September 1, 2019, through the end of the study period (March 31, 2021), disenrollment, or death, whichever occurred first.

Among persons included in the cohort, data were collected on hospitalizations that had respiratory virus testing performed or associated with acute respiratory illness (using International Classification of Disease [ICD-10] codes) (Supplementary Table 1). Hospitalizations in patients were included if admission occurred between March 1, 2020, and March 31, 2021, and the length of stay was ≥24 hours. Re-admissions in which an admission date occurred within 30 days of a prior discharge date were combined and analyzed as a single hospitalization, consistent with another study on COVID-19-associated health care encounters [9].

Definitions

We defined a COVID-19–associated hospitalization based on either the presence of COVID-19 ICD-10 discharge diagnosis codes (U07.1 or U07.2) or a positive SARS-CoV-2 result performed ≤14 days before through 72 hours after admission from a molecular assay, rapid antigen test, or culture. For the analysis, we used the first COVID-19–associated hospitalization within the participating health systems within the study period for an individual. Adults were considered to have an underlying condition based on the presence of an ICD-10 diagnosis code (Supplementary Table 2) from ≥1 inpatient or outpatient encounter during the look-back period. Clinical outcomes, including admission to the intensive care unit, in-hospital death, and select discharge diagnoses (eg, COVID-19-associated pneumonia, acute respiratory distress syndrome), and acute exacerbations (based on discharge diagnoses) of underlying conditions were identified based on influenza and SARS-CoV-2 literature (Supplementary Table 2) [10, 11].

Statistical Analysis

Using the patient cohort as the denominator, risks (per 100 000 population), risk ratios (RRs), and 95% confidence intervals were estimated using a modified Poisson regression with robust error variance. Risks of COVID-19–associated hospitalizations and clinical outcomes were stratified by both age and self-reported race/ethnicity. For the race/ethnicity category, adults who identified as not Hispanic, but Asian or Pacific Islander, American Indian or Alaskan Native, and multiple races were categorized as non-Hispanic adults of other races. Risks and RRs were adjusted for health system. For RRs, non-Hispanic White adults aged 18–64 years were used as the reference group. Among patients with select underlying conditions who were hospitalized with COVID-19, we examined the proportions with acute exacerbations of underlying conditions that occurred during that hospitalization; proportions were stratified by age and race/ethnicity. We included those with missing data on the 3 variables with incomplete data, though we excluded those with missing data on race/ethnicity for stratified analyses. As a secondary analysis, we calculated risks of COVID-19–associated hospitalization stratified by age, race/ethnicity, and sex to understand whether and how much sex may impact stratified risks. As a sensitivity analysis, we calculated risks of laboratory-confirmed SARS-CoV-2 hospitalizations; for HP, we only included in-network hospitalizations, as test results were not available from claims for out-of-network hospitalizations. All analyses were conducted using SAS software, version 9.4 (Cary, NC, USA). This study was reviewed and approved by the Westat, Inc., institutional review board (45 C.F.R. part 46; 21 C.F.R. part 56).

RESULTS

Description of Patient Cohort and Patients With COVID-19-Associated Hospitalizations

After implementing the health care utilization and membership/insurance eligibility criteria described above, 2 608 922 adults were included in the patient cohort. Among these patients, 58% were women, 45% were aged 18–49 years, and 56% were non-Hispanic White. Half of the patients had no underlying condition documented (Table 1). From March 1, 2020, through March 31, 2021, 6879 adults were hospitalized with COVID-19: 5143 (75%) had a COVID-19 discharge diagnosis with laboratory-confirmed SARS-CoV-2 infection, and 1492 (22%) had a COVID-19 diagnosis but had no linked SARS-CoV-2 test associated with the hospitalization; 244 (3%) had a COVID-19 diagnosis but a negative SARS-CoV-2 test result. COVID-19 hospitalizations occurred equally in men and women, and proportions were similar across age groups. A higher proportion of adults hospitalized with COVID-19 were of Hispanic ethnicity or had an underlying condition (29% and 84%, respectively) compared with the patient cohort (11% and 50%, respectively) (Table 1).

COVID-19-Associated Hospitalization Risks

Through the first 13 months of the COVID-19 pandemic, the cumulative risk of COVID-19–associated hospitalizations was 264 per 100 000 population (Table 2). Monthly COVID-19–associated hospitalization risks were similar across May–October 2020 (range, 9–14 per 100 000 population), peaked during November 2020–January 2021 (highest risk, 55 per

Table 1. Characteristics of Persons Included in the Patient Cohort and Persons Hospitalized With COVID-19 Between March 2020 and March 2021

Characteristics	Patient Cohort (n = 2 608 922), No. (%)	Persons Hospitalized With COVID-19 (n = 6879), No. (%)
Sex		
Male	1 096 019 (42)	3426 (50)
Female	1 512 149 (58)	3452 (50)
Unknown	754 (0)	1 (0)
Age (as of September 1, 2019)		
18–49 y	1 175 723 (45)	1541 (22)
50–64 y	703 196 (27)	2000 (29)
65–74 y	431 199 (16)	1503 (22)
≥75 y	298 804 (11)	1835 (27)
Race/ethnicity		
Non-Hispanic White	1 461 027 (56)	3232 (47)
Non-Hispanic Black	103 641 (4)	553 (8)
Hispanic	293 189 (11)	1967 (29)
Non-Hispanic other races[a]	213 843 (8)	603 (9)
Unknown	537 222 (21)	524 (8)
Underlying conditions[b]		
No underlying conditions recorded	1 314 647 (50)	1124 (16)
Chronic lung disease	267 955 (10)	2018 (29)
Asthma	159 097 (6)	790 (11)
Chronic obstructive Pulmonary disease	85 819 (3)	924 (13)
Cardiovascular disease	338 234 (13)	2843 (41)
Heart failure	61 716 (2)	971 (14)
Ischemic heart disease	130 994 (5)	1378 (20)
Diabetes	237 100 (9)	2401 (35)
Other metabolic disease	563 465 (22)	2064 (30)
Liver disease	89 797 (3)	652 (9)
Renal disease	149 819 (6)	1841 (27)
Immunosuppression	400 395 (15)	2556 (37)
Malignancy	215 699 (8)	955 (14)
Neurological/musculoskeletal disorder	261 684 (10)	1901 (28)
Blood disorders	37 642 (1)	327 (5)
Cerebrovascular disease	47 315 (2)	494 (7)
Primary insurance type		
Medicare	408 612 (16)	2017 (29)
Medicaid	236 736 (9)	1246 (18)
Private insurance	576 079 (22)	1063 (15)
Other	900 091 (34)	1162 (18)
Unknown	487 404 (19)	1391 (20)
Prior health care utilization[b] (number of encounters by type)		
General practice		
0	1 233 481 (47)	3049 (44)
1–5	1 034 871 (40)	2084 (30)
6–19	300 571 (12)	1463 (21)
≥20	39 999 (1)	283 (4)
Medical specialty		
0	306 924 (12)	389 (6)
1–5	1 390 065 (53)	2387 (35)
6–19	662 794 (25)	2170 (32)
≥20	249 139 (10)	1933 (28)
Emergency department or urgent care		
0	2 090 093 (80)	3682 (54)
1–5	457 385 (18)	2452 (36)
6–19	57 587 (2)	668 (10)
≥20	3857 (0)	77 (1)
Hospitalizations		
0	2 410 743 (92)	5055 (73)
≥1	198 179 (8)	1824 (27)

Abbreviation: COVID-19, coronavirus disease 2019.

[a]Other races include Asian or Pacific Islander, American Indian or Alaskan Native, and multiple races.

[b]Ascertained during look-back period (September 1, 2018, through September 1, 2019).

100 000 population), and then declined by March 2021 to pre-winter surge risks (Figure 1). This pattern was similarly observed when limited to laboratory-confirmed SARS-CoV-2 hospitalizations (Figure 1).

Cumulative hospitalization risks increased with increasing age, from a risk of 131 per 100 000 population in adults aged 18–49 years to 614 in those aged ≥75 years (Table 2). Hispanic and non-Hispanic Black adults had the highest hospitalization risks (671 and 534 per 100 000 population, respectively), compared with non-Hispanic White adults and non-Hispanic adults of other races (221 and 282 per 100 000 population, respectively). Risks were lower but similar when we restricted to laboratory-confirmed SARS-CoV-2 hospitalization (Supplementary Table 3).

Risks and Risk Ratios of COVID-19-Associated Hospitalization and Clinical Outcomes by Age and Race/Ethnicity

COVID-19–associated hospitalization risks further stratified by both age and race/ethnicity reflected greater heterogeneity across strata, including particularly high risks among older adults of Hispanic race and non-White race, than when stratified by age or race/ethnicity alone. Within each racial/ethnic group, risks across all clinical outcomes were higher among adults aged ≥65 years than those aged 18–64 years (Table 3).

Non-Hispanic White adults aged 18–64 years had the lowest hospitalization risk (133 per 100 000). Compared with this group, other age and racial/ethnic groups had significantly higher COVID-19-associated hospitalization risks, particularly non-Hispanic Black and Hispanic adults aged ≥65 years. When risks were further stratified by sex, we observed the same pattern, though within each stratum of age and race/ethnicity, risks were higher in men than in women (Supplementary Table 4). Among adults aged 18–64 years, RRs ranged from 1.4 for non-Hispanic adults of other races to 2.8 for non-Hispanic Black adults to 4.2 for Hispanic adults. Among adults aged ≥65 years, RRs were 3.0

Table 2. Risks of COVID-19–Associated Hospitalizations (per 100 000 Population)

Characteristics	No. of COVID-19–Associated Hospitalizations	Patient Cohort	Risk per 100 000 Population (95% CI)
Total	6879	2 608 922	264 (257–270)
Sex			
Male	3426	1 096 019	313 (302–323)
Female	3452	1 512 149	228 (221–236)
Unknown	1	754	133 (0–392)
Age (as of September 1, 2019)			
18–49 y	1541	1 175 723	131 (125–138)
50–64 y	2000	703 196	284 (272–297)
65–74 y	1503	431 199	349 (331–366)
≥75 y	1835	298 804	614 (586–642)
Race/ethnicity			
Non-Hispanic White	3232	1 461 027	221 (214–229)
Non-Hispanic Black	553	103 641	534 (489–578)
Hispanic	1967	293 189	671 (641–700)
Other races[a]	603	213 843	282 (260–304)
Unknown	524	537 222	98 (89–106)
Underlying conditions[b]			
No underlying conditions recorded	1124	1 314 647	85 (81–90)
At least 1 underlying condition recorded	5755	1 294 275	445 (434–456)
Chronic lung disease	2018	267 955	753 (720–785)
Asthma	790	159 097	497 (462–531)
Chronic obstructive pulmonary disease	924	85 819	1078 (1008–1146)
Cardiovascular disease	2843	338 234	841 (810–871)
Heart failure	971	61 716	1573 (1475–1672)
Ischemic heart disease	1378	130 994	1052 (997–1107)
Diabetes	2401	237 100	1013 (972–1053)
Other metabolic disease	2064	563 465	366 (351–382)
Liver disease	652	89 797	726 (671–782)
Renal disease	1841	149 819	1229 (1173–1285)
Immunosuppression	2556	400 395	638 (614–663)
Malignancy	955	215 699	443 (415–471)
Neurological/musculoskeletal disorder	1901	261 684	726 (694–759)
Blood disorders	327	37 642	869 (775–962)
Cerebrovascular disease	494	47 315	1044 (952–1136)

Abbreviation: COVID-19, coronavirus disease 2019.

[a]Other races include Asian or Pacific Islander, American Indian or Alaskan Native, and multiple races. Among the 175 062 persons who identified as Asian or Pacific Islander, 470 had COVID-19-associated hospitalizations, for an estimated risk of 268 (95% CI, 244–293) per 100 000 population. Among the 5836 persons who identified as American Indian or Alaskan Native, 26 had COVID-19-associated hospitalizations, for an estimated risk of 446 (95% CI, 275–616) per 100 000 population. Among the 32 945 persons who identified as being multiracial, 107 had COVID-19-associated hospitalizations, for an estimated risk of 325 (95% CI, 263–386) per 100 000 population. For stratified analyses, these 3 racial/ethnic groups were combined, in part due to the wide confidence intervals within some groups.

[b]Ascertained during the look-back period (September 1, 2018, through September 1, 2019).

for non-Hispanic White adults, 6.5 for non-Hispanic adults of other races, 8.6 for non-Hispanic Black adults, and 9.3 for Hispanic adults (Table 3).

As shown in Table 3, risks of admission to the intensive care unit (ICU) followed a similar trend, with risks being lowest in non-Hispanic White adults aged 18–64 years (29.2 per 100 000). Risk ratios were highest in non-Hispanic Black adults aged ≥65 years and Hispanic adults aged ≥65 years (RR, 11.4; 95% CI, 8.8–14.8; and RR, 11.4; 95% CI, 9.4–13.8, respectively). Although risks of invasive mechanical ventilation and in-hospital death were lower within each stratum of age and race/ethnicity, the highest risk ratios were consistently observed among non-Hispanic Black adults aged ≥65 years (RR, 15.0; 95% CI, 10.6–21.3; and RR, 20.8; 95% CI, 13.0–33.5, respectively) and Hispanic adults aged ≥65 years (RR, 16.5; 95% CI, 12.7–21.3; and RR, 36.9; 95% CI, 26.5–51.4, respectively) compared with non-Hispanic White adults aged 18–64 years. Risk ratios of COVID-19–associated pneumonia were higher among adults aged ≥65 years, particularly those who were non-Hispanic Black or Hispanic (RR, 5.8; 95% CI, 4.1–8.3; and RR, 7.6; 95% CI, 6.0–9.5, respectively).

Acute Exacerbations of Underlying Conditions Among Patients With Select Underlying Conditions and Hospitalized With COVID-19

Compared with adults of other age and racial/ethnic groups who were hospitalized with COVID-19, non-Hispanic Black

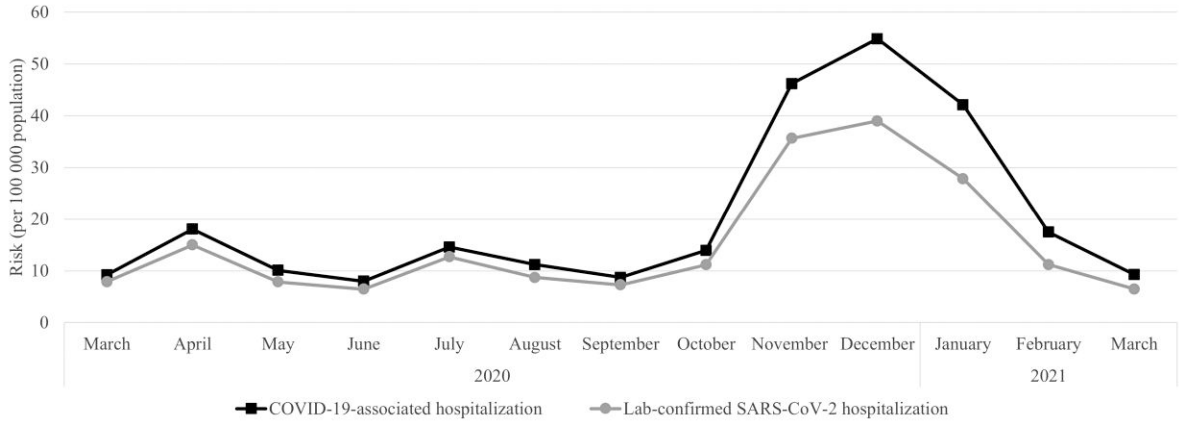

Figure 1. Population-based risks of COVID-19–associated and laboratory-confirmed SARS-CoV-2 hospitalizations by month of admission. For the denominator in estimating monthly risks, we started using the entire patient cohort and then restricted data each month to include only those people in the cohort who were still alive, enrolled in the health care system, and had not been hospitalized with COVID-19 for that particular month. Abbreviations: COVID-19, coronavirus disease 2019; SARS-CoV-2, severe acute respiratory syndrome coronavirus 2.

adults aged ≥65 years had the highest prevalence of COPD, chronic lung disease, renal disease, and cardiovascular disease (Supplementary Table 5). Of the acute exacerbations of underlying conditions examined that co-occurred with the COVID-19–associated hospitalization, respiratory failure among adults with chronic lung disease who were hospitalized with COVID-19 was the most common (54.8%; range across strata of age and race/ethnicity, 45.8%–62.9%) (Figure 2). Although the prevalence of asthma was low overall and similar across the strata of age and race/ethnicity (range, 7.8%–16.9%), 48.1% of all adults with asthma who were hospitalized with COVID-19 had an acute asthma exacerbation during that hospitalization, ranging from 35.7% to 66.7% across strata. Among patients with renal disease or cardiovascular disease and hospitalized with COVID-19 across strata of age and race/ethnicity, the highest proportion of acute renal failure and congestive heart failure occurred in non-Hispanic Black adults aged ≥65 years (55.5% and 43.9%, respectively). Among patients with chronic lung disease or asthma and hospitalized with COVID-19, the highest proportions of respiratory failure and asthma exacerbation, respectively, occurred in Hispanic adults aged ≥65 years (62.9% and 66.7%, respectively).

DISCUSSION

Within a cohort of >2.6 million patients across 4 health care systems, COVID-19–associated hospitalization risks during the first year of the COVID-19 pandemic were highest among older adults and non-Hispanic Black and Hispanic adults. Risk ratios stratified by age and race/ethnicity further illustrated the large disparity in and persistence of the risk of severe COVID-19 disease resulting in hospitalization and adverse clinical outcomes, particularly in older non-Hispanic Black and Hispanic adults, who consistently had the highest risk ratios. Although the occurrence of acute exacerbations of underlying conditions varied across groups of age and race/ethnicity, older non-Hispanic Black adults overall had the highest prevalence of these select underlying conditions. Among patients with these conditions who were hospitalized with COVID-19, the highest proportion of acute exacerbations occurred in older, non-Hispanic Black and Hispanic adults.

Higher relative risks of COVID-19–associated hospitalization of certain racial/ethnic groups, particularly in individuals of older ages, have been reported during the first year of the COVID-19 pandemic in the United States, continuing to highlight that certain groups are disproportionately affected by COVID-19 [1–5]. Many previous examinations of racial and ethnic disparities related to COVID-19 hospitalizations were limited to the first few months of the pandemic and within single health care systems. A study using regional integrated health care systems in California found that Hispanic and Black patients had the highest hospitalization rates (219.6 and 123.1 per 100 000 population, respectively), particularly compared with White patients who had the lowest rate, 55.1, during February–May 2020 [7]. Other studies within single health care systems observed that Black persons were 1.7–2.0 more likely to be hospitalized with COVID-19 than White or other racial and ethnic minority groups [3, 4, 12]. Another study of COVID-19 hospitalizations across 14 states found that non-Hispanic Black and Hispanic patients of all ages had higher age-adjusted hospitalization rate ratios (RR, 2.85; 95% CI, 2.81–2.89; and RR, 3.06; 95% CI, 3.01–3.10, respectively), compared with non-Hispanic White patients from March 2020 to February 2021 [6]. Similarly, our study observed that the age- and race/ethnicity-related disparities in hospitalization risks appear to have persisted.

Table 3. Risks and Risk Ratios of COVID-19–Associated Hospitalization and Clinical Outcomes Stratified by Age and Race/Ethnicity[a]

Clinical Outcomes	All Adults Aged ≥18 Years (n = 2 608 922)	Non-Hispanic White Adults Aged 18–64 Years (n = 973 956)		Non-Hispanic Black Adults Aged 18–64 Years (n = 82 004)		Hispanic Adults Aged 18–64 Years (n = 243 869)		Non-Hispanic Adults of Other Races Aged 18–64 Years (n = 132 993)		Non-Hispanic White Adults Aged ≥65 Years (n = 487 071)		Non-Hispanic Black Adults Aged ≥65 Years (n = 21 637)		Hispanic Adults Aged ≥65 Years (n = 49 320)		Non-Hispanic Adults of Other Races Aged ≥65 Years (n = 47 905)	
	Risk (per 100 000 Population)	Risk (per 100 000 Population)	Risk Ratio (95% CI)	Risk (per 100 000 Population)	Risk Ratio (95% CI)	Risk (per 100 000 Population)	Risk Ratio (95% CI)	Risk (per 100 000 Population)	Risk Ratio (95% CI)	Risk (per 100 000 Population)	Risk Ratio (95% CI)	Risk (per 100 000 Population)	Risk Ratio (95% CI)	Risk (per 100 000 Population)	Risk Ratio (95% CI)	Risk (per 100 000 Population)	Risk Ratio (95% CI)
COVID-19–associated hospitalization	263.7	133.1	Ref	370.7	2.8 (2.5–3.2)	555.6	4.2 (3.9–4.5)	186.8	1.4 (1.2–1.6)	397.5	3.0 (2.8–3.2)	1150.8	8.6 (7.6–9.9)	1240.9	9.3 (8.5–10.3)	554	6.5 (5.7–7.4)
Invasive mechanical ventilation	32.8	12.9	Ref	54.9	4.2 (3.0–6.0)	84.5	6.5 (5.2–8.1)	26.5	2.0 (1.4–2.9)	36.8	2.8 (2.3–3.6)	194.1	15.0 (10.6–21.3)	212.9	16.5 (12.7–21.3)	93.9	7.0 (5.3–10.0)
Admission to the intensive care unit	64.3	29.2	Ref	74.4	2.6 (1.9–3.4)	133.7	4.6 (3.9–5.4)	51.1	1.8 (1.4–2.2)	96.1	3.3 (2.8–3.8)	332.8	11.4 (8.8–14.8)	332.5	11.4 (9.4–13.8)	137.8	4.5 (3.5–5.8)
In-hospital death	25.9	5.5	Ref	23.2	4.2 (2.5–7.0)	31.2	5.6 (4.0–8.0)	12.0	2.2 (1.2–3.8)	62.6	11.3 (8.5–15.1)	115.5	20.8 (13.0–33.5)	204.8	36.9 (26.5–51.4)	81.2	14.7 (9.9–21.8)
Discharge diagnoses	…	…	…	…	…	…	…	…	…	…	…	…	…	…	…	…	…
Pneumonia of any etiology	147.4	69.8	Ref	158.5	2.3 (1.9–2.7)	292.4	4.2 (3.8–4.7)	174.4	1.4 (1.1–1.6)	232.6	3.3 (3.0–3.7)	582.3	8.3 (6.9–10.1)	764.4	10.9 (9.7–12.4)	346.6	4.6 (3.9–5.4)
Viral (includes COVID-19, influenza, and other viruses)	129.5	59.1	Ref	129.3	2.2 (1.8–2.7)	263.3	4.5 (4.0–5.0)	87.7	1.4 (1.2–1.7)	201.2	3.4 (3.1–3.8)	536.1	9.1 (7.4–11.1)	679.2	11.5 (10.0–13.1)	274.4	4.5 (3.8–5.4)
Bacterial and other etiology	45.2	22.4	Ref	57.3	2.6 (1.9–3.5)	79.1	3.5 (2.9–4.3)	34.7	1.2 (0.9–1.5)	76.8	3.4 (2.9–4.1)	161.8	7.2 (5.1–10.3)	241.3	10.8 (8.6–13.5)	162.4	5.4 (4.3–6.9)
COVID-19 pneumonia	47.3	27.8	Ref	53.7	1.9 (1.4–2.7)	70.5	2.5 (2.1–3.1)	25.9	0.9 (0.6–1.2)	88.1	3.2 (2.7–3.7)	161.8	5.8 (4.1–8.3)	210.9	7.6 (6.0–9.5)	77.2	2.5 (1.8–3.5)
Influenza disease	0.7	0.4	Ref	0.0	–	0.8	2.0 (0.4–10.9)	0.0	–	2.1	5.0 (1.6–15.9)	9.2	22.5 (4.1–122.9)	2.0	4.9 (0.6–44.2)	0.0	–
Acute respiratory distress syndrome	136.4	63.5	Ref	139.0	2.2 (1.8–2.7)	250.5	3.9 (3.5–4.4)	97.2	1.4 (1.2–1.7)	224.6	3.5 (3.2–3.9)	573.1	9.0 (7.4–11.0)	746.1	11.8 (10.3–13.4)	333.9	4.8 (4.1–5.7)
Respiratory failure	22.4	9.7	Ref	22.0	2.3 (1.4–3.8)	61.5	6.4 (4.9–8.2)	17.7	1.8 (1.7–2.7)	25.7	2.7 (2.0–3.5)	83.2	8.6 (5.2–14.3)	141.9	14.7 (10.8–20.0)	65.0	6.5 (4.5–9.6)
Sepsis	69.3	27.6	Ref	81.7	3.0 (2.3–3.9)	151.7	5.5 (4.7–6.4)	68.2	2.0 (1.6–2.4)	98.5	3.6 (3.1–4.1)	328.1	11.9 (9.1–15.4)	367.0	13.3 (11.0–16.0)	231.1	6.6 (5.4–8.1)
Acute kidney failure	66.9	23.2	Ref	97.6	4.2 (3.3–5.4)	125.9	5.4 (4.6–6.4)	44.2	1.4 (1.1–1.9)	110.0	4.7 (4.1–5.5)	503.8	21.7 (17.3–27.3)	383.2	16.5 (13.6–20.0)	218.4	7.2 (5.8–8.8)
Multisystem inflammatory syndrome	2.3	0.3	Ref	1.2	4.0 (0.4–38.1)	4.1	13.3 (3.7–48.4)	0.0	–	5.3	17.3 (5.2–57.3)	9.2	30.0 (5.0–179.6)	20.3	65.8 (18.1–239.2)	8.3	8.8 (3.5–21.8)

Abbreviation: COVID-19, coronavirus disease 2019.

[a]Six hundred thirty-one persons with COVID-19-associated hospitalizations were excluded due to missing data on race/ethnicity.

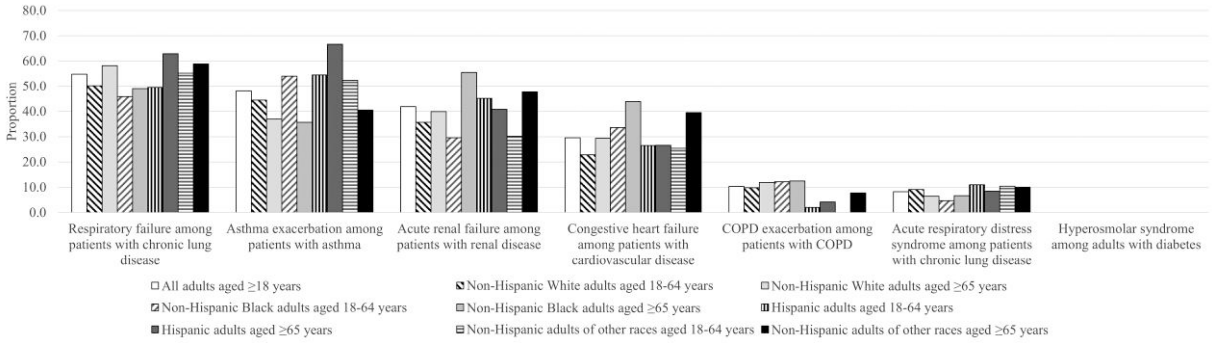

Figure 2. Percentage of acute exacerbations of chronic conditions among persons hospitalized with COVID-19 with select underlying conditions. Six hundred thirty-one persons with COVID-19-associated hospitalizations were excluded due to missing data on race/ethnicity. Abbreviations: COPD, chronic obstructive pulmonary disease; COVID-19, coronavirus disease 2019.

We also observed the highest risk ratios of adverse clinical outcomes, including ICU admission and in-hospital death, among older Hispanic and non-Hispanic Black adults, compared with younger, non-Hispanic White adults. Another analysis showed that rates of ICU admission and in-hospital death increased with increasing age among Hispanic adults, Black adults, and White adults during the first year of the pandemic; within each age group, rates for both outcomes were higher for Hispanic adults, followed by Black adults, compared with White adults [6]. However, in the Acosta et al. study, ICU admission and in-hospital death were ascertained for sampled hospitalized COVID-19 patients, so frequencies were weighted to calculate rates. Studies have shown that once hospitalized, Black race was not associated with ICU admission [2, 3, 12], invasive mechanical ventilation [12, 13], or in-hospital death [2, 4, 12, 14] compared with White race. Few studies have observed that Hispanic or non-Hispanic Black adults did not have increased risk of severe outcomes [7, 15, 16]. However, studies with relative risks of select COVID-19–associated clinical outcomes (including COVID-19–associated pneumonia) or that examined the occurrence of acute exacerbations of underlying conditions are sparse. We observed that older Hispanic patients with asthma and hospitalized with COVID-19 had the highest proportion of asthma exacerbation. Another study, which followed asthmatic patients after their SARS-CoV-2 infection for a mean of 6.8 months, similarly observed that Latino patients with asthma had significantly higher odds of developing asthma exacerbation and a longer duration of asthma exacerbation symptoms compared with Black and White patients with asthma [17]. Hispanic patients with asthma may have increased susceptibility to prolonged respiratory inflammation during or after SARS-CoV-2 infection, though further investigation is warranted.

The higher relative risks of hospitalization, ICU admission, in-hospital death, and other adverse clinical outcomes across racial and ethnic minorities, particularly those of older ages, observed in our analysis are likely multifactorial. In our patient cohort, older, non-Hispanic Black adults had the highest prevalence of chronic lung disease, renal disease, cardiovascular disease, and diabetes, which could contribute to the higher risks of severe COVID-19 disease in this population [2, 3, 8, 18]. Further, adults with these underlying conditions and hospitalized with COVID-19 also had the highest proportion of acute renal failure, congestive heart failure, and COPD exacerbation. However, we could not ascertain whether COVID-19, the acute exacerbation, or something else resulted in the hospitalization. In addition, a recent systematic review of racial and ethnic disparities related to COVID-19 suggested that disparities may be due to exposure-related factors and health care access rather than susceptibility (in part due to comorbid conditions) [19]; delayed use of health care (eg, due to cost, despite symptoms) may also contribute [20, 21]. Community-level exposure to COVID-19 could be a large driver of disparities in severe COVID-19 disease [22, 23]. Black and Hispanic persons may be more likely to be essential workers in industries that could also increase the risk of exposure to COVID-19 [24–27]. Downstream effects on health that stem from structural racism, including decreased access to health care, may also contribute [28–30]. Access to care may be less of a concern among patients in this study because our patient cohort was constructed based on prior health care utilization and, at 2 sites, health system membership/insurance, but it is an important consideration for other studies. In this study, SARS-CoV-2 testing rates across racial/ethnic groups and the timing of testing relative to hospitalization were similar across strata of age and race/ethnicity (data not shown), though we could not ascertain when care was sought relative to symptom onset, if applicable. Collectively, these factors may influence health outcomes, including observed risks of COVID-19 disease resulting in hospitalization.

While published COVID-19–associated hospitalization risks are limited, we found that laboratory-confirmed SARS-CoV-2

hospitalization risks among adults aged ≥18 years using the VISION network data were lower than rates from a population-based surveillance system focused on laboratory-confirmed COVID-19 (COVID-NET [COVID-19 Hospitalizations; cdc.gov]), even when we compared the state-specific rates between networks for the 4 states that overlapped. COVID-NET was designed to capture all community- and hospital-acquired laboratory-confirmed SARS-CoV-2 cases (from molecular or rapid antigen testing) within a defined geographic area. In contrast, the VISION Network includes hospitals from select health care systems in an area, so community-acquired COVID-19-associated hospitalization risks will be subject to patients seeking care in those hospitals. Further, risks were estimated using a patient cohort based on prior health care utilization and therefore may reflect a population that was employed and/or had health insurance. The observed disparity across age and race/ethnicity among patients who may be more engaged in health care and/or more affluent may indicate the strength of and complex factors driving these disparities. In addition, the COVID-19–associated hospitalizations in our analytic data were among those with acute respiratory illness diagnoses or those with a respiratory virus test performed. Despite the lower risks observed using VISION data, creating a population-based denominator using electronic health records allows for the opportunity to describe the population from whom health outcomes were observed, particularly in terms of prior health care utilization and underlying conditions from a look-back period.

The strengths of our study include a sample of health systems and the utilization of a large patient cohort based on membership/insurance criteria and health care utilization before the COVID-19 pandemic. This patient cohort aided in understanding differences between those who had sought care within the health systems and the subset of patients who were hospitalized with COVID-19. Because underlying conditions were ascertained during a look-back period, we could examine the occurrence of acute exacerbations of select conditions during the COVID-19-associated hospitalization.

This analysis is subject to limitations. First, constructing the cohort based on prior health care utilization may reflect patients of higher socioeconomic status (SES). The geographic locations of these health systems, including the racial and ethnic compositions of their served populations, are unlikely to be representative of the United States. Taken together, our findings may not be generalizable to the entire country. We did not anticipate bias based on sites' locations, though our models adjusted for health system; patterns of findings were consistent across each site (data not shown) despite any potential variation in intensity of local SARS-CoV-2 circulation during the study period. Further, if SES or other similar factors are associated with inclusion in the patient cohort and with the outcome, selection bias may be possible, and these risks and risk ratios may be underestimated if persons who may be of lower SES and also at higher risk for COVID-19–associated hospitalizations and clinical outcomes were not included in the cohort. Second, data on social determinants and social vulnerability were not collected, and thus we were unable to examine how these factors could have contributed to the differences in risks across racial/ethnic groups. Third, our ability to define acute exacerbations of chronic conditions was limited to diagnosis codes, and we were unable to collect data on medications or from chart review to better ascertain whether exacerbations occurred. Additionally, ascertainment of invasive mechanical ventilation may be incomplete for sites relying in part on claims data, so these risks may be underestimated.

This study indicates that racial and ethnic minority groups, particularly those of older ages, were disproportionately affected by severe COVID-19 during the first year of the COVID-19 pandemic. Further research is needed to understand the complex relationship between race/ethnicity and COVID-19–associated outcomes, particularly with a focus on the role of social determinants. Disentangling these factors could facilitate informing interventions to reduce barriers and improve health. These findings from the first year of the pandemic indicate that ensuring equitable access to health care (and encouraging engagement with health care) and preventive measures, including vaccination, is critical for persons of racial and ethnic minorities.

Supplementary Data

Supplementary materials are available at *Open Forum Infectious Diseases* online. Consisting of data provided by the authors to benefit the reader, the posted materials are not copyedited and are the sole responsibility of the authors, so questions or comments should be addressed to the corresponding author.

Acknowledgments

We thank Padma Dandamudi and Brad Crane at Kaiser Permanente Northwest.

Financial support. This study was supported by the Centers for Disease Control and Prevention though contract 75D30120C07986 to Westat, Inc. Study sponsors placed no limitations on publication and did not require confidentiality in reporting of results.

Disclaimer. The findings and conclusions in this report are those of the authors and do not necessarily represent the official position of the Centers for Disease Control and Prevention.

Potential conflicts of interest. Allison Naleway received research funding from Pfizer and Vir Biotechnology unrelated to the study. All other authors report no potential conflicts. All authors have submitted the ICMJE Form for Disclosure of Potential Conflicts of Interest. Conflicts that the editors consider relevant to the content of the manuscript have been disclosed.

Patient consent. The design of the study has been approved by local ethics committees (including the Westat, Inc., Institutional Review Board) in the United States. This study did not include factors necessitating patient consent.

References

1. Garg S, Kim L, Whitaker M, et al. Hospitalization rates and characteristics of patients hospitalized with laboratory-confirmed coronavirus disease 2019—COVID-NET, 14 states, March 1–30, 2020. MMWR Morb Mortal Wkly Rep **2020**; 69:458–64.

2. Kim L, Garg S, O'Halloran A, et al. Risk factors for intensive care unit admission and in-hospital mortality among hospitalized adults identified through the US coronavirus disease 2019 (COVID-19)-associated hospitalization surveillance network (COVID-NET). Clin Infect Dis **2021**; 72:e206–14.
3. Gu T, Mack JA, Salvatore M, et al. Characteristics associated with racial/ethnic disparities in COVID-19 outcomes in an academic health care system. JAMA Netw Open **2020**; 3:e2025197.
4. Price-Haywood EG, Burton J, Fort D, Seoane L. Hospitalization and mortality among black patients and white patients with COVID-19. N Engl J Med **2020**; 382:2534–43.
5. Stokes EK, Zambrano LD, Anderson KN, et al. Coronavirus disease 2019 case surveillance—United States, January 22–May 30, 2020. MMWR Morb Mortal Wkly Rep **2020**; 69:759–65.
6. Acosta AM, Garg S, Pham H, et al. Racial and ethnic disparities in rates of COVID-19-associated hospitalization, intensive care unit admission, and in-hospital death in the United States from March 2020 to February 2021. JAMA Netw Open **2021**; 4:e2130479.
7. Escobar GJ, Adams AS, Liu VX, et al. Racial disparities in COVID-19 testing and outcomes: retrospective cohort study in an integrated health system. Ann Intern Med **2021**; 174:786–93.
8. Ko JY, Danielson ML, Town M, et al. Risk factors for coronavirus disease 2019 (COVID-19)-associated hospitalization: COVID-19-associated hospitalization surveillance network and behavioral risk factor surveillance system. Clin Infect Dis **2021**; 72:e695–703.
9. Thompson MG, Stenehjem E, Grannis S, et al. Effectiveness of COVID-19 vaccines in ambulatory and inpatient care settings. N Engl J Med **2021**; 385:1355–71.
10. Cates J, Lucero-Obusan C, Dahl RM, et al. Risk for in-hospital complications associated with COVID-19 and influenza—Veterans Health Administration, United States, October 1, 2018–May 31, 2020. MMWR Morb Mortal Wkly Rep **2020**; 69:1528–34.
11. Chow EJ, Rolfes MA, O'Halloran A, et al. Respiratory and nonrespiratory diagnoses associated with influenza in hospitalized adults. JAMA Netw Open **2020**; 3:e201323.
12. Munoz-Price LS, Nattinger AB, Rivera F, et al. Racial disparities in incidence and outcomes among patients with COVID-19. JAMA Netw Open **2020**; 3:e2021892.
13. Goyal P, Choi JJ, Pinheiro LC, et al. Clinical characteristics of COVID-19 in New York city. N Engl J Med **2020**; 382:2372–4.
14. Yehia BR, Winegar A, Fogel R, et al. Association of race with mortality among patients hospitalized with coronavirus disease 2019 (COVID-19) at 92 US hospitals. JAMA Netw Open **2020**; 3:e2018039.
15. Kabarriti R, Brodin NP, Maron MI, et al. Association of race and ethnicity with comorbidities and survival among patients with COVID-19 at an urban medical center in New York. JAMA Netw Open **2020**; 3:e2019795.
16. Ogedegbe G, Ravenell J, Adhikari S, et al. Assessment of racial/ethnic disparities in hospitalization and mortality in patients with COVID-19 in New York City. JAMA Netw Open **2020**; 3:e2026881.
17. Foster K, Jaswaney R, Moore D, Andy-Nweye A, Mahdavinia M. Latinos experience longer duration of uncontrolled asthma after COVID infection. Paper presented at: American College of Allergy, Asthma, and Immunology Annual Scientific Meeting; November 4–8, **2021**; New Orleans, LA.
18. Tartof SY, Qian L, Hong V, et al. Obesity and mortality among patients diagnosed with COVID-19: results from an integrated health care organization. Ann Intern Med **2020**; 173:773–81.
19. Mackey K, Ayers CK, Kondo KK, et al. Racial and ethnic disparities in COVID-19-related infections, hospitalizations, and deaths: a systematic review. Ann Intern Med **2021**; 174:362–73.
20. Azar KMJ, Shen Z, Romanelli RJ, et al. Disparities in outcomes among COVID-19 patients in a large health care system in California. Health Aff (Millwood) **2020**; 39:1253–62.
21. McMorrow S, Kenney GM, Goin D. Determinants of receipt of recommended preventive services: implications for the affordable care act. Am J Public Health **2014**; 104:2392–9.
22. Martinez DA, Hinson JS, Klein EY, et al. SARS-CoV-2 positivity rate for Latinos in the Baltimore-Washington, DC region. JAMA **2020**; 324:392–5.
23. Millett GA, Jones AT, Benkeser D, et al. Assessing differential impacts of COVID-19 on black communities. Ann Epidemiol **2020**; 47:37–44.
24. Hawkins D. Differential occupational risk for COVID-19 and other infection exposure according to race and ethnicity. Am J Ind Med **2020**; 63:817–20.
25. Podewils LJ, Burket TL, Mettenbrink C, et al. Disproportionate incidence of COVID-19 infection, hospitalizations, and deaths among persons identifying as Hispanic or Latino—Denver, Colorado March–October 2020. MMWR Morb Mortal Wkly Rep **2020**; 69:1812–6.
26. Raine S, Liu A, Mintz J, Wahood W, Huntley K, Haffizulla F. Racial and ethnic disparities in COVID-19 outcomes: social determination of health. Int J Environ Res Public Health **2020**; 17:8115.
27. The Lancet. The plight of essential workers during the COVID-19 pandemic. Lancet **2020**; 395:1587.
28. Bailey ZD, Feldman JM, Bassett MT. How structural racism works—racist policies as a root cause of U.S. racial health inequities. N Engl J Med **2021**; 384:768–73.
29. Hardeman RR, Medina EM, Kozhimannil KB. Structural racism and supporting Black lives—the role of health professionals. N Engl J Med **2016**; 375:2113–5.
30. Paradies Y, Priest N, Ben J, et al. Racism as a determinant of health: a protocol for conducting a systematic review and meta-analysis. Syst Rev **2013**; 2:e0138511.