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

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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,
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, 6,879 adults were hospitalized with COVID-19: 5,143 (75%) had a COVID-19 discharge diagnosis with laboratory-confirmed SARS-CoV-2 infection, and 1,492 (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 = 687,968), No. (%) |
|-----------------|-----------------------------------------|---------------------------------------------------------|
| **Sex**         |                                         |                                                         |
| Male            | 1,096,019 (42)                          | 342 (50)                                                |
| Female          | 1,512,149 (58)                          | 342 (50)                                                |
| Unknown         | 754 (0)                                 | 1 (0)                                                   |
| **Age (as of September 1, 2019)** |                                     |                                                         |
| 18–49 y         | 1,175,723 (45)                          | 1,541 (22)                                              |
| 50–64 y         | 703,196 (27)                            | 2,000 (29)                                              |
| 65–74 y         | 431,199 (16)                            | 1,503 (22)                                              |
| ≥75 y           | 298,804 (11)                            | 1,835 (27)                                              |
| **Race/ethnicity** |                                         |                                                         |
| Non-Hispanic White | 1,461,027 (56)                     | 323 (47)                                                |
| Non-Hispanic Black | 103,641 (4)                         | 553 (8)                                                 |
| Hispanic         | 293,189 (11)                            | 1,967 (29)                                              |
| Non-Hispanic other races | 213,843 (8)                        | 603 (9)                                                 |
| Unknown          | 537,222 (21)                            | 524 (8)                                                 |
| **Underlying conditions** |                                         |                                                         |
| No underlying conditions recorded | 1,314,647 (50)                       | 1,124 (16)                                              |
| Chronic lung disease | 267,955 (10)                        | 2,018 (29)                                              |
| Asthma           | 159,097 (6)                             | 790 (11)                                                |
| Chronic obstructive Pulmonary disease | 85,819 (3)                         | 924 (13)                                                |
| Cardiovascular disease | 338,234 (13)                        | 2,843 (41)                                              |
| Heart failure    | 61,716 (2)                              | 971 (14)                                                |
| Ischemic heart disease | 130,994 (5)                         | 1,378 (20)                                              |
| Diabetes         | 237,100 (9)                             | 2,401 (35)                                              |
| Other metabolic disease | 563,465 (22)                       | 2,064 (30)                                              |
| Liver disease    | 89,797 (3)                              | 652 (9)                                                 |
| Renal disease    | 149,819 (6)                             | 1,841 (27)                                              |
| Immunosuppression | 400,395 (15)                         | 2,556 (37)                                              |
| Malignancy       | 215,699 (8)                             | 955 (14)                                                |
| Neurological/musculoskeletal disorder | 261,684 (10)                       | 1,901 (28)                                              |
| Blood disorders  | 37,642 (1)                              | 327 (6)                                                 |
| Cerebrovascular disease | 47,315 (2)                       | 494 (7)                                                 |
| **Primary insurance type** |                                         |                                                         |
| Medicare         | 408,612 (16)                            | 2,017 (29)                                              |
| Medicaid         | 236,736 (9)                             | 1,246 (18)                                              |
| Private insurance | 576,079 (22)                         | 1,063 (15)                                              |
| Other            | 900,091 (34)                            | 1,162 (18)                                              |
| Unknown          | 487,404 (19)                            | 1,391 (20)                                              |
| **Prior health care utilization** | (number of encounters by type) |                                                         |
| General practice |                                         |                                                         |
| 0               | 1,233,481 (47)                          | 3,049 (44)                                              |
| 1–5             | 1,034,871 (40)                          | 2,084 (30)                                              |
| 6–19            | 300,571 (12)                            | 1,463 (21)                                              |
| ≥20             | 39,999 (1)                              | 283 (4)                                                 |
| Medical specialty |                                         |                                                         |
| 0               | 306,924 (12)                            | 399 (6)                                                  |
| 1–5             | 1,390,065 (53)                          | 2,387 (35)                                              |
| 6–19            | 662,794 (25)                            | 2,170 (32)                                              |
| ≥20             | 249,139 (10)                            | 1,933 (28)                                              |
| Emergency department or urgent care |                                         |                                                         |
| 0               | 2,090,093 (80)                          | 3,682 (64)                                              |

Abbreviation: COVID-19, coronavirus disease 2019.

*Other races include Asian or Pacific Islander, American Indian or Alaskan Native, and multiple races.

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, RR 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, RR were 3.0
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).

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

| Characteristics                  | No. of COVID-19–Associated Hospitalizations | 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                          | 1,541                                      | 1,175,723                           | 131 (125–138)                     |
| 50–64 y                          | 2,000                                      | 703,196                              | 284 (272–297)                     |
| 65–74 y                          | 1,503                                      | 431,199                              | 349 (331–366)                     |
| ≥75 y                            | 1,835                                      | 298,804                              | 614 (586–642)                     |
| **Race/ethnicity**               |                                            |                                     |                                    |
| Non-Hispanic White               | 3,322                                      | 1,461,027                            | 221 (214–229)                     |
| Non-Hispanic Black               | 553                                        | 103,641                              | 534 (489–578)                     |
| Hispanic                         | 1,967                                      | 293,189                              | 671 (641–700)                     |
| Other races*                     | 603                                        | 213,843                              | 282 (260–304)                     |
| Unknown                          | 524                                        | 537,222                              | 98 (89–106)                       |
| **Underlying conditions**        |                                            |                                     |                                    |
| No underling conditions recorded | 1,124                                      | 1,314,647                            | 85 (81–90)                        |
| At least 1 underling condition recorded | 5,755                                      | 1,294,275                            | 445 (434–456)                     |
| Chronic lung disease             | 2,018                                      | 267,965                              | 753 (720–785)                     |
| Asthma                           | 790                                        | 159,097                              | 497 (462–531)                     |
| Chronic obstructive pulmonary disease | 924                                        | 85,819                               | 1,078 (1,008–1,148)              |
| Cardiovascular disease           | 2,843                                      | 338,234                              | 841 (810–871)                     |
| Heart failure                    | 971                                        | 61,716                               | 1,573 (1,475–1,672)              |
| Ischemic heart disease           | 1,378                                      | 130,994                              | 1,052 (997–1,107)                |
| Diabetes                         | 2,401                                      | 237,100                              | 1,013 (972–1,053)                |
| Other metabolic disease          | 2,064                                      | 563,465                              | 366 (351–382)                     |
| Liver disease                    | 652                                        | 89,797                               | 726 (671–782)                     |
| Renal disease                    | 1,841                                      | 149,819                              | 1,229 (1,173–1,285)              |
| Immunosuppression                | 2,556                                      | 400,395                              | 638 (614–663)                     |
| Malignancy                       | 955                                        | 215,699                              | 443 (415–471)                     |
| Neurological/musculoskeletal disorder | 1,901                                      | 261,684                              | 726 (694–759)                     |
| Blood disorders                  | 327                                        | 37,642                               | 869 (775–962)                     |
| Cerebrovascular disease          | 494                                        | 47,315                               | 1,044 (952–1,136)                |

Abbreviation: COVID-19, coronavirus disease 2019.

*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, 244–290) 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.

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

| Clinical Outcomes                                    | All Adults Aged ≥18 Years (n = 2,832) | 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 = 2,436,689) | Non-Hispanic Adults of Other Races Aged 18–64 Years (n = 132,983) | 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 = 43,320) | 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)                  |
| COVID-19–associated hospitalization                  | 263.7                                 | 133.1 Ref                                               | 370.7 2.8 (2.5–3.2)                                    | 555.6 4.3 (3.9–4.9)                             | 186.8 1.4 (1.3–1.6)                           | 397.5 3.0 (2.8–3.2)                           | 1,150.8 8.6 (7.6–9.9)                          | 1,340.9 9.3 (8.5–10.3)                       | 954 6.5 (5.7–7.4)                               |
| Invasive mechanical ventilation                      | 32.8                                 | 12.9 Ref                                                | 54.9 4.2 (3.6–4.9)                                    | 84.5 5.0 (4.6–5.4)                             | 26.5 2.0 (1.7–2.3)                           | 36.8 2.8 (2.4–3.3)                           | 194.1 15.0 (12.9–19.3)                        | 212.9 16.5 (14.2–22.3)                       | 93.9 7.0 (5.3–10.0)                            |
| Admission to the intensive care unit                 | 64.3                                 | 29.2 Ref                                                | 74.4 2.6 (2.3–2.9)                                    | 133.7 4.6 (3.9–5.6)                             | 51.1 1.8 (1.4–2.4)                           | 96.1 3.3 (2.8–3.8)                           | 332.8 11.4 (8.4–14.8)                        | 332.5 11.4 (8.4–14.8)                        | 137.8 4.5 (3.5–6.8)                            |
| In-hospital death                                    | 25.9                                 | 5.5 Ref                                                 | 23.2 4.2 (3.7–4.9)                                    | 31.2 5.6 (5.0–6.2)                             | 12.0 2.2 (1.7–2.8)                           | 63.6 11.3 (8.5–15.1)                         | 115.5 20.8 (17.0–24.9)                       | 204.8 30.9 (26.5–35.4)                       | 81.2 14.7 (9.9–21.8)                           |
| Discharge diagnoses                                  |                                      |                                                         |                                                        |                                                |                                                |                                                |                                                |                                                |                                                |
| Pneumonia of any etiology                           | 147.4                                | 69.8 Ref                                                | 158.5 2.3 (2.0–2.7)                                    | 292.4 4.2 (3.8–4.7)                             | 174.4 1.4 (1.1–1.7)                           | 232.6 3.3 (3.0–3.7)                           | 982.3 8.3 (6.8–10.1)                         | 764.4 10.9 (8.7–12.4)                        | 346.6 4.6 (3.9–5.4)                            |
| Vial (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 (1.1–1.7)                            | 201.2 3.4 (3.1–3.8)                           | 156.1 9.1 (7.4–11.1)                         | 679.2 11.5 (10.0–13.1)                       | 274.4 4.5 (3.5–6.5)                            |
| Bacterial and other etiology                         | 45.2                                 | 22.4 Ref                                                | 57.3 2.6 (2.3–2.9)                                    | 79.1 3.5 (3.2–3.9)                             | 34.7 1.2 (0.9–1.5)                            | 70.8 3.4 (2.9–4.1)                            | 161.8 7.2 (5.8–9.3)                          | 241.3 10.8 (8.6–13.3)                        | 162.4 5.4 (4.4–6.6)                            |
| COVID-19 pneumonia                                   | 47.3                                 | 21.8 Ref                                                | 63.7 2.9 (2.4–3.7)                                    | 70.5 2.5 (2.1–3.3)                             | 25.0 0.9 (0.6–1.3)                            | 88.1 3.2 (2.7–3.7)                            | 161.8 5.8 (4.6–7.4)                          | 219.9 7.6 (6.0–9.5)                          | 172.2 2.6 (1.9–3.6)                            |
| Influenza pneumonia                                  | 0.7                                  | 0.4 Ref                                                 | 0.0                                                    | 0.8 2.0 (0.4–10.9)                             | 0.0 –                                         | 2.1 5.0 (0.9–27.5)                            | 9.2 2.2 (1.1–12.2)                           | 2.0 4.0 (0.6–44.2)                           | 0.0 –                                         |
| Acute respiratory distress syndromes                | 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 (1.1–1.7)                            | 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 (3.4–6.6)                            |
| Respiratory failure                                  | 22.4                                 | 9.7 Ref                                                 | 22.0 2.3 (1.9–2.8)                                    | 61.5 6.4 (4.9–8.2)                             | 17.7 1.8 (1.5–2.3)                            | 26.7 2.7 (2.0–3.5)                            | 83.2 6.6 (5.2–8.4)                          | 141.9 14.7 (10.9–20.0)                       | 65.0 6.4 (4.9–9.6)                            |
| Sepsis                                               | 69.3                                 | 27.6 Ref                                                | 81.7 3.0 (2.3–3.9)                                    | 151.7 5.1 (4.7–5.6)                             | 66.2 2.0 (1.6–2.4)                            | 99.5 3.6 (3.1–4.3)                            | 328.1 11.9 (9.3–16.4)                        | 367.0 13.3 (11.0–16.0)                       | 231.1 6.6 (5.4–8.6)                            |
| Acute kidney failure                                 | 66.9                                 | 23.2 Ref                                                | 97.6 4.2 (3.6–4.9)                                    | 125.9 5.4 (4.6–6.8)                             | 44.2 1.4 (1.1–1.9)                            | 110.0 4.7 (4.1–5.5)                           | 903.8 21.7 (17.3–27.9)                       | 383.2 16.5 (13.0–20.9)                       | 218.4 7.2 (5.4–8.6)                            |
| Multisystem inflammatory syndrome                   | 2.3                                  | 0.3 Ref                                                 | 1.2 4.0 (3.4–3.8)                                    | 4.1 13.3 (3.7–48.4)                             | 0.0 –                                         | 5.3 17.3 (5.2–57.3)                           | 9.2 30.0 (2.8–74.4)                          | 20.3 65.8 (18.1–219.2)                       | 8.3 8.8 (3.5–21.8)                            |

Abbreviation: COVID-19, coronavirus disease 2019.

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

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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.

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