Clinical Infectious Diseases

MAJOR ARTICLE

# Patient Characteristics and Outcomes of 11 721 Patients With Coronavirus Disease 2019 (COVID-19) Hospitalized Across the United States

**Michael W. Fried,[1] Julie M. Crawford,[1] Andrea R. Mospan,[1] Stephanie E. Watkins,[1] Breda Munoz,[1] Richard C. Zink,[1] Sherry Elliott,[2] Kyle Burleson,[1] Charles Landis,[3] K. Rajender Reddy,[4] and Robert S. Brown Jr[5]**

[1]TARGET PharmaSolutions Inc., Durham, North Carolina, USA, [2]Elliott Health Information Pros Inc., Cary, North Carolina, USA, [3]Liver Care and Transplantation Services at University of Washington Medical Center, Seattle, Washington, USA, [4]Department of Medicine, University of Pennsylvania, Philadelphia, Pennsylvania, USA, and [5]Department of Medicine, Division of Gastroenterology and Hepatology, Weill Cornell Medicine Center for Liver Disease, New York, New York, USA

***Background.*** As coronavirus disease 2019 (COVID-19) disseminates throughout the United States, a better understanding of the patient characteristics associated with hospitalization, morbidity, and mortality in diverse geographic regions is essential.

***Methods.*** Hospital chargemaster data on adult patients with COVID-19 admitted to 245 hospitals across 38 states between 15 February and 20 April 2020 were assessed. The clinical course from admission, through hospitalization, and to discharge or death was analyzed.

***Results.*** A total of 11 721 patients were included (majority were >60 years of age [59.9%] and male [53.4%]). Comorbidities included hypertension (46.7%), diabetes (27.8%), cardiovascular disease (18.6%), obesity (16.1%), and chronic kidney disease (12.2%). Mechanical ventilation was required by 1967 patients (16.8%). Mortality among hospitalized patients was 21.4% and increased to 70.5% among those on mechanical ventilation. Male sex, older age, obesity, geographic region, and the presence of chronic kidney disease or a preexisting cardiovascular disease were associated with increased odds of mechanical ventilation. All aforementioned risk factors, with the exception of obesity, were associated with increased odds of death (all $P$ values < .001). Many patients received investigational medications for treatment of COVID-19, including 48 patients on remdesivir and 4232 on hydroxychloroquine.

***Conclusions.*** This large observational cohort describes the clinical course and identifies factors associated with the outcomes of hospitalized patients with COVID-19 across the United States. These data can inform strategies to prioritize prevention and treatment for this disease.

**Keywords.** SARS-CoV-2; COVID-19; observational study; hydroxychloroquine; remdesivir.

Severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) [1] is a novel coronavirus identified initially in Wuhan, China, in 2019. The virus causes coronavirus disease 2019 (COVID-19) [2], which subsequently has created outbreaks across the world, resulting in over 5.2 million cases and over 327 000 deaths globally [3]. In the United States, the first case of COVID-19 was reported on 20 January 2020 in Washington state [4]. As of 5 August 2020, there have been over 4.6 million confirmed cases and 154 952 deaths attributed to COVID-19 in the United States [3].

In early reports in China and the United States, increasing age and comorbid diseases, most notably cardiovascular disease, diabetes, hypertension, and chronic kidney disease, were associated with increased disease severity and death [5–7]. According to the Centers for Disease Control and Prevention (CDC) COVID-network (NET) surveillance system, 89% of patients hospitalized in March 2020 with a laboratory-confirmed infection had at least 1 underlying comorbid condition [8].

As the COVID-19 pandemic is rapidly evolving, population-based studies in the United States evaluating the patient characteristics associated with hospitalization and survival are limited. Previous studies have examined the characteristics associated with morbidity and mortality, but they represent, at most, 14 states and 10% of the US population [8]. As there are multiple investigational agents being assessed for the treatment of COVID-19, an understanding of the phenotypical characteristics associated with health outcomes in population-based studies will be important for public health planning and to assess the effectiveness of novel therapies. The aim of this study was to examine those patient characteristics associated with morbidity and mortality among patients hospitalized in the United States.

## METHODS

### Data Source

Deidentified hospital claims data from the hospital chargemaster, consisting of a comprehensive list of all billable products,

Received 5 June 2020; editorial decision 19 August 2020; accepted 24 August 2020; published online August 28, 2020.

Correspondence: M. W. Fried, TARGET PharmaSolutions, Inc., 2520 Meridian Pkwy, Suite 105, Durham, NC 27713 (mfried@targetpharmasolutions.com).

**Clinical Infectious Diseases® 2021;72(10):e558–65**



DOI: 10.1093/cid/ciaa1268

procedures, and services provided to inpatients, were acquired from a commercially available source representing adults receiving inpatient care between 15 February and 20 April 2020 at 245 hospitals across 38 states in the United States. As it does not constitute human subject research, this research was determined to be exempt from institutional review board approval, based on federal regulation 45 Code of Federal Regulations 46 and associated guidance.

#### Study Population and Patient Characteristics

Variables of interest at the time of admission for a patient's first hospitalization with a COVID-19 diagnosis included hospital type, patient demographics, and the presence of comorbid conditions. Comorbidities were captured using International Classification of Disease, Tenth Revision (ICD-10), codes indicating the presence of a chronic condition at the time of admission and from hospital encounters within 12 months up to the date of admission. Those ICD-10 codes used to classify comorbid disease were identified by expert opinion, and cross-referenced with validated methods from health services research to define comorbid medical conditions from the claims data (Supplementary Table 1) [9].

#### Characteristics of Hospitalization

The need for either oxygen supplementation or mechanical ventilation was captured at admission and over the course of the patient's hospitalization (Supplementary Table 1). The highest level of oxygen supplementation required during hospitalization was classified based on charge codes. Patients with pneumonia and no other billable codes indicating a higher level of oxygen support any time during hospitalization were assumed to have received a minimum of low-flow oxygen; those without these features were assigned to the no-oxygen category. Whether the patient required intensive care unit (ICU) level of care or the use of putative therapies, including select medications under investigation for COVID-19, were also captured.

#### Statistical Analysis

Differences in the proportions and means of demographics, comorbidities, and characteristics of the patients' hospitalization were compared by the need for mechanical ventilation, using a chi-squared test and Kruskal-Wallis test for categorical and continuous variables, respectively. For expected cell counts less than 5, Fisher's exact test was used to determine statistically significant differences in proportions.

The associations between demographic characteristics and comorbid disease at admission and the odds of both death and the need for mechanical ventilation were estimated using multivariable logistic regression. Based on previous literature, the associations of the following risk factors with morbidity and mortality were investigated: age, sex, insurance status at admission, history of chronic kidney disease, stage 5 kidney disease, hypertension, diabetes, pulmonary disease, cardiovascular disease, liver disease, obesity, and smoking. The location of hospitals was also included in the models in order to explore regional disparities in outcomes, using regions defined by the US Census Bureau as Northeast, Midwest, South, and West [10].

All variables were entered as either dichotomous or categorical variables. Age was categorized into the following groups: 18–40 years, 41–60 years, and >60 years. Insurance status was categorized into a 4-level variable: commercial, Medicaid, Medicare, and other. Patient histories of select comorbid diseases were modeled as dichotomous variables. Odds ratios (ORs) and corresponding 95% confidence intervals (CIs) were provided for each risk factor.

### RESULTS

#### Demographics and Comorbid Disease

The study population included 11 721 patients aged ≥18 years who were admitted between 15 February and 20 April 2020 across 245 hospitals with an ICD-10 code indicating COVID-19 infection, including 9057 (77%) with the confirmatory ICD-10 code released after 1 April 2020. Patient demographics and comorbid conditions are shown in Table 1. Of the hospitalized patients, 60% were >60 years and approximately half (53.4%) were male. Numerous comorbid conditions were common among those who were hospitalized for COVID-19. Hypertension was present in 46.7% of the patients in this cohort, diabetes in 27.8%, cardiovascular disease in 18.6%, obesity in 16.1%, and chronic kidney disease in 12.2%. A history of pulmonary disease was present for 14.8% of patients, and 16.4% of patients had a history of smoking ($n = 1922$). At admission, 167 patients were pregnant. More than 50% of patients were admitted to hospitals in the Northeast (53.9%), followed by the South (32.4%), West (9.6%), and Midwest (4.1%) regions of the United States. In terms of insurance status, more patients were on Medicare (45.3%) than were on commercial insurance (26.6%), were on Medicaid (12.8%), and had other insurance or an unknown insurance status (15.3%; Table 1).

#### Characteristics of Hospitalization

The median duration of hospitalization for all patients from admission to either discharge or death was 7.0 days (range, 2.0–60.0 days). At the time of the data cutoff, 617 (5.3%) patients were still hospitalized. Pneumonia was present in 52.4% of patients within 24 hours of admission, while a total of 84.0% had evidence of pneumonia at some point during hospitalization. The highest level of oxygen supplementation during admission was noted to be low-flow O2 in 7570 patients (64.6%), high-flow O2 in 643 patients (5.5%), and mechanical ventilation in 1967 patients (16.8%). There were 1541 (13.1%) patients who were categorized as not receiving oxygen support. An ICU level of care was received by 20% of patients ($n = 2336$), with a median length of ICU stay of 5 days (range, 1.0–60.0 days).

**Table 1. Characteristics of Adult Patients Hospitalized for Coronavirus Disease 2019**

| Characteristics | Mechanical ventilation needs: Needed MV,[a] n = 1967 | Mechanical ventilation needs: Did not need MV, n = 9754 | Total, n = 11 721 | P value[b] |
|---|---|---|---|---|
| Demographics | | | | |
| Age group, n (%), y | … | … | … | <.0001 |
| 18–40 | 111 (5.6) | 1155 (11.8) | 1266 (10.8) | |
| 41–60 | 533 (27.1) | 2903 (29.8) | 3436 (29.3) | |
| >60 | 1323 (67.3) | 5696 (58.4) | 7019 (59.9) | |
| Sex, n (%) | … | … | … | <.0001 |
| Female | 710 (36.1) | 4747 (48.7) | 5457 (46.6) | |
| Male | 1257 (63.9) | 5007 (51.3) | 6264 (53.4) | |
| Insurance, n (%) | … | … | … | <.0001 |
| Commercial | 470 (23.9) | 2653 (27.2) | 3123 (26.6) | |
| Medicaid | 208 (10.6) | 1292 (13.2) | 1500 (12.8) | |
| Medicare | 998 (50.7) | 4312 (44.2) | 5310 (45.3) | |
| Other[c] | 291 (14.8) | 1497 (15.3) | 1788 (15.3) | |
| Hospital type, n (%)[d] | … | … | … | <.0001 |
| Major teaching | 859 (43.7) | 4363 (44.7) | 5222 (44.6) | |
| Minor teaching | 303 (15.4) | 1857 (19.0) | 2160 (18.4) | |
| Nonteaching | 805 (40.9) | 3534 (36.2) | 4339 (37.0) | |
| Census region, n (%) | … | … | … | .0009 |
| Midwest | 80 (4.1) | 401 (4.1) | 481 (4.1) | |
| Northeast | 1028 (52.3) | 5289 (54.2) | 6317 (53.9) | |
| South | 622 (31.6) | 3176 (32.6) | 3798 (32.4) | |
| West | 237 (12.0) | 888 (9.1) | 1125 (9.6) | |
| Comorbid disease[e] | | | | |
| History of diabetes, n (%) | 624 (31.7) | 2630 (27.0) | 3254 (27.8) | <.0001 |
| History of obesity, n (%) | 360 (18.3) | 1531 (15.7) | 1891 (16.1) | .0042 |
| History of hypertension, n (%) | 941 (47.8) | 4534 (46.5) | 5475 (46.7) | .2716 |
| History of cardiovascular disease, n (%) | 444 (22.6) | 1738 (17.8) | 2182 (18.6) | <.0001 |
| History of cerebrovascular disease, n (%) | 114 (5.8) | 693 (7.1) | 807 (6.9) | .0365 |
| History of pulmonary disease, n (%) | 275 (14.0) | 1462 (15.0) | 1737 (14.8) | .2510 |
| History of chronic kidney disease, n (%) | 299 (15.2) | 1128 (11.6) | 1427 (12.2) | <.0001 |
| History of chronic kidney disease, Stage 5, n (%) | 84 (4.3) | 343 (3.5) | 427 (3.6) | .1035 |
| History of smoking, n (%) | 293 (14.9) | 1629 (16.7) | 1922 (16.4) | .0486 |
| History of liver disease, n (%) | 34 (1.7) | 113 (1.2) | 147 (1.3) | .0382 |
| History of solid organ transplant, n (%) | 12 (.6) | 84 (.9) | 96 (.8) | .2597 |
| History of BMT/SCT, n (%) | 2 (.1) | 16 (.2) | 18 (.2) | .5194 |
| History of non–skin cancer malignancy, n (%) | 129 (6.6) | 713 (7.3) | 842 (7.2) | .2390 |
| History of peripheral vascular disease, n (%) | 64 (3.3) | 258 (2.6) | 322 (2.7) | .1320 |
| History of HIV/AIDS, n (%) | 17 (.9) | 94 (1.0) | 111 (.9) | .6778 |
| History of autoimmune, RA/SLE, n (%) | 21 (1.1) | 147 (1.5) | 168 (1.4) | .1347 |
| Inflammatory bowel disease, n (%) | 4 (.2) | 28 (.3) | 32 (.3) | .5163 |
| Current pregnancy, n (%) | 5 (.3) | 162 (1.7) | 167 (1.4) | <.0001 |

Abbreviations: BMT, bone marrow transplant; HIV, human immunodeficiency virus; MV, mechanical ventilation; RA, rheumatoid arthritis; SCT, stem cell transplant; SLE, systemic lupus erythematosus.

[a]Includes 6 patients on extracorporeal membrane oxygenation.

[b]Chi-square or Fisher exact test *P* values are reported, comparing those who needed MV to those who did not.

[c]Other category includes both other and unknown insurance status.

[d]Major teaching includes hospitals that are members of the Council of Teaching Hospitals; and minor includes those that are not members but that have accredited residency programs.

[e]Patients may have multiple comorbidities.

Most hospitalized patients were discharged alive (73.3%), but 21% of patients died, after a median length of stay of 8.0 days (range, 2.0–60.0 days; Table 2). Among those patients who died, the proportion of deaths increased with age: 2.1% among patients 18–40 years, 13.6% among those 41–60, and 84.3% among patients >60 years ($P < .0001$; data not shown).

### Characteristics of Patients Requiring Mechanical Ventilation

Mechanical ventilation was required during hospitalization for 16.8% patients. Among all patients, including 6 on extracorporeal membrane oxygenation, 785 patients (6.7%) were mechanically ventilated within 24 hours of admission. Those who required any mechanical ventilation over the course of their hospitalization were more likely than those who did not to be male (63.9% vs 51.3%, respectively; $P < .0001$) and over the age of 60 years (67.3% vs 58.4%, respectively; $P < .0001$). Histories of chronic kidney disease (15.2% vs 11.6%, respectively; $P < .0001$), cardiovascular disease (22.6% vs 17.8%, respectively; $P < .001$), diabetes (31.7% vs 27.0%, respectively; $P < .0001$), and obesity (18.3% vs 15.7%, respectively; $P < .0042$) were more frequent among those who required mechanical ventilation than those who did not (Table 1). The median length of stay for patients requiring mechanical ventilation was 4 days longer than patients who required only low-flow, high-flow, or no oxygen supplementation (11.0 vs 7.0 days, respectively; $P < .0001$). The median time from admission to receiving mechanical ventilation was 2.0 days (range, 1.0–33.0 days). The proportion of patients who died increased from 11.6% in those who only required low-flow, high-flow, or no oxygen supplementation to 70.5% among those requiring mechanical ventilation ($P < .001$; Table 2). An increasing trend was observed among patients requiring mechanical ventilation, with 5.6%, 27.1%, and 67.3% using mechanical ventilation as the age groups increased (18–40, 41–60, and >60 years, respectively; $P < .0001$; Table 1).

The risk factors associated with mechanical ventilation include male sex, advancing age (>60 years and 41–60 years), obesity, geographic region, the presence of chronic kidney disease, or cardiovascular disease. The odds of needing mechanical ventilation were lower in patients with a history of hypertension or smoking (Figure 1*A*).

Increased odds of mortality were associated with advancing age, the presence of chronic kidney disease, cardiovascular disease, male sex, having noncommercial insurance, and living in the Northeast region. In an adjusted multivariable logistic model, the odds of death among patients over the age of 60 years was 7.2 times (95% CI, 5.4–9.7) that of patients aged between 18 and 40 years. Patients between the ages of 41 and 60 were also at an increased risk as compared to those aged 18–40 (OR, 2.6; 95% CI, 1.9–3.5), yet the risk was attenuated. Males were 46% (OR, 1.5; 95% CI, 1.3–1.6) more likely to die than females. The odds of death were lower in

**Table 2. Characteristics of Hospitalization Among Adult Patients Hospitalized with Coronavirus Disease 2019**

| | Mechanical ventilation needs | | | |
|---|---|---|---|---|
| Characteristics | Needed MV, n = 1967[a] | Did not need MV, n = 9754 | Total, n = 11 721 | P value[b] |
| Discharge disposition, n (%) | | | | <.0001 |
| Discharged home | 515 (26.2) | 8075 (82.8) | 8590 (73.3) | |
| Dead | 1386 (70.5) | 1128 (11.6) | 2514 (21.4) | |
| Still in the hospital | 66 (3.4) | 551 (5.6) | 617 (5.3) | |
| Total duration hospitalization, all patients, admission to discharge/death, days | | | | <.0001 |
| Median (n) | 11.0 (1901) | 7.0 (9203) | 7.0 (11104) | |
| Min–max | 2.0–46.0 | 2.0–60.0 | 2.0–60.0 | |
| Total duration of hospitalization for survivors, days | | | | <.0001 |
| Median (n) | 15.0 (515) | 7.0 (8075) | 7.0 (8590) | |
| Min–max | 2.0–45.0 | 2.0–57.0 | 2.0–57.0 | |
| Total duration of hospitalizations for those who died, days | | | | <.0001 |
| Median (n) | 9.0 (1386) | 7.0 (1128) | 8.0 (2514) | |
| Min–max | 2.0–46.0 | 2.0–60.0 | 2.0–60.0 | |
| ICU level of care, n (%) | 1967 (100.0) | 369 (3.8) | 2336 (19.9) | <.0001 |
| Highest level of $O_2$ supplied within 24 h of admission, n (%) | | | | <.0001 |
| No oxygen supplementation | 345 (17.5) | 3695 (37.9) | 4040 (34.5) | |
| Low flow[c] | 777 (39.5) | 5785 (59.3) | 6562 (56.0) | |
| High flow | 60 (3.1) | 274 (2.8) | 334 (2.8) | |
| Mechanical ventilation[d,e] | 785 (39.9) | NA | 785 (6.7) | |
| Highest level of $O_2$ ever, n (%) | | | | <.0001 |
| No oxygen supplementation | — | 1541 (15.8) | 1541 (13.1) | |
| Low flow[c] | NA | 7570 (77.6) | 7570 (64.6) | |
| High flow | NA | 643 (6.6) | 643 (5.5) | |
| Mechanical ventilation[a] | 1967 (100.0) | NA | 1967 (16.8) | |
| Time from date of admission to first day of mechanical ventilation, days[d] | | | | |
| Median (n) | 2.0 (1967) | NA | 2.0 (1967) | |
| Min–max | 1.0–33.0 | NA | 1.0–33.0 | |
| Duration on ICU, days | | | | <.0001 |
| Median (n) | 5.0 (1967) | 2.0 (369) | 5.0 (2336) | |
| Min–max | 1.0–60.0 | 1.0–34.0 | 1.0–60.0 | |
| Presence of pneumonia within 24 h of admission, n (%) | 1059 (53.8) | 5077 (52.1) | 6136 (52.4) | .1475 |
| Presence of pneumonia at any time, n (%) | 1873 (95.2) | 7974 (81.8) | 9847 (84.0) | <.0001 |
| COVID-19 therapy received at hospital | | | | |
| Hydroxychloroquine treatment, n (%) | 1054 (53.6) | 3178 (32.6) | 4232 (36.1) | <.0001 |
| Remdesivir treatment, n (%) | 11 (.6) | 37 (.4) | 48 (.4) | .2544 |
| Other treatment,[f] n (%) | 228 (11.6) | 137 (1.4) | 365 (3.1) | <.0001 |

Abbreviations: COVID-19, coronavirus disease 2019; ECMO, extracorporeal membrane oxygenation; ICU, intensive care unit; max, maimum; min, minimum; MV, mechanical ventilation; NA, not applicable.

[a]Of these patients, 6 were on ECMO.

[b]Chi-square, Fisher exact test, or Kruskal Wallis test *P* values are reported, comparing those who needed MV to those who did not.

[c]Patients with a diagnosis of pneumonia and no other billable codes indicating a higher level of oxygen support were assumed to have received a minimum of low-flow oxygen.

[d]There were 39 patients with an indeterminant admission status when MV was initiated who were assumed to have been put on MV on Day 1.

[e]Of these patients, 3 were on ECMO.

[f]Other treatments included tocilizumab, sarilumab, and lopinavir/ritonavir.

patients with a history of hypertension, pulmonary disease, or smoking (Figure 1*B*).

Patients who ever needed mechanical ventilation during hospitalization, controlling for demographics and comorbid disease, were 32.0 times (95% CI, 27.5–37.2) as likely to die as patients whose highest level of oxygen supplementation was low-flow, high-flow, or no oxygen (Supplementary Figure 1). The magnitude of the association of ventilatory status with mortality was also dependent on the timing of when patients were initially placed on mechanical ventilation; those on mechanical ventilation within 24 hours of admission (OR, 16.9; 95% CI, 13.9–20.5) had better outcomes than those requiring mechanical ventilation later in their hospital course (OR, 31.1; 95% CI, 26.0–37.4; Supplementary Figure 2).

### Putative COVID-19 Therapies

Although there are no approved treatments for COVID-19, the US Food and Drug Administration recently issued emergency use authorization for remdesivir [11]. While treatment in this study was not stratified by severity of disease, to date, 48 hospitalized patients in this cohort have been treated with remdesivir, and 44 patients (91.7%) were discharged. Changes in the oxygen support level from hospital admission to discharge or death among patients who were administered remdesivir are shown in Figure 2. The median number of days that remdesivir was administered was 5.0 (range, 1.0–10.0), and 33.3% of patients received treatment for fewer than 5.0 days (data not shown). The 4 deaths occurred among the 11 patients who were on mechanical ventilation during hospitalization, for mortality rates of 36.4% among those on mechanical ventilation and 8.3% overall for all patients treated with remdesivir, independent of their level of oxygen support (Supplementary Table 2).

Over 4200 patients (36.1%) were treated with hydroxychloroquine, a medication approved for various rheumatologic diseases and the treatment of malaria that has demonstrated laboratory evidence of efficacy against SARS-CoV-2 [12, 13]. Patients treated with hydroxychloroquine were less likely to have the following comorbidities: diabetes, hypertension, cardiovascular disease, pulmonary disease, obesity, chronic kidney disease (including stage 5), and liver disease. Patients treated with hydroxychloroquine were more likely to be on mechanical ventilation than those who did not receive hydroxychloroquine (24.9% vs 12.2%, respectively). The unadjusted mortality rate for patients treated with hydroxychloroquine was 24.8%, compared to 19.6% among those who did not receive hydroxychloroquine (Supplementary Table 3).

## DISCUSSION

The epidemiology, risk factors, and outcomes of patients with COVID-19 are under intense study, and best management

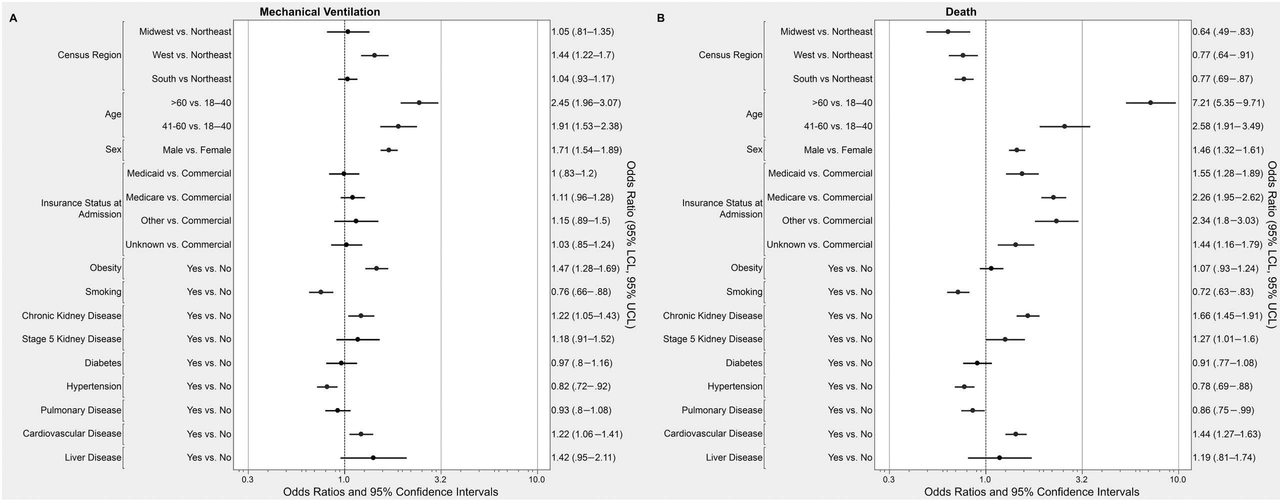


**Figure 1.** Odds ratios and 95% confidence intervals from multivariable logistic regression models for (*A*) mechanical ventilation or (*B*) death for adult hospitalized patients with COVID-19. Odds ratio estimates are adjusted for all other variables in the model. Abbreviations: COVID-19, coronavirus disease 2019; LCL, lower confidence limit; UCL, upper confidence limit.

practices are rapidly evolving. To date, several case series have provided important information regarding the course of COVID-19 in hospitalized patients [6, 14, 15]. The majority of reports have focused on patients hospitalized in "hot spot" regions of China or the United States, and often included data ascertained from single hospital systems [5, 14–16].

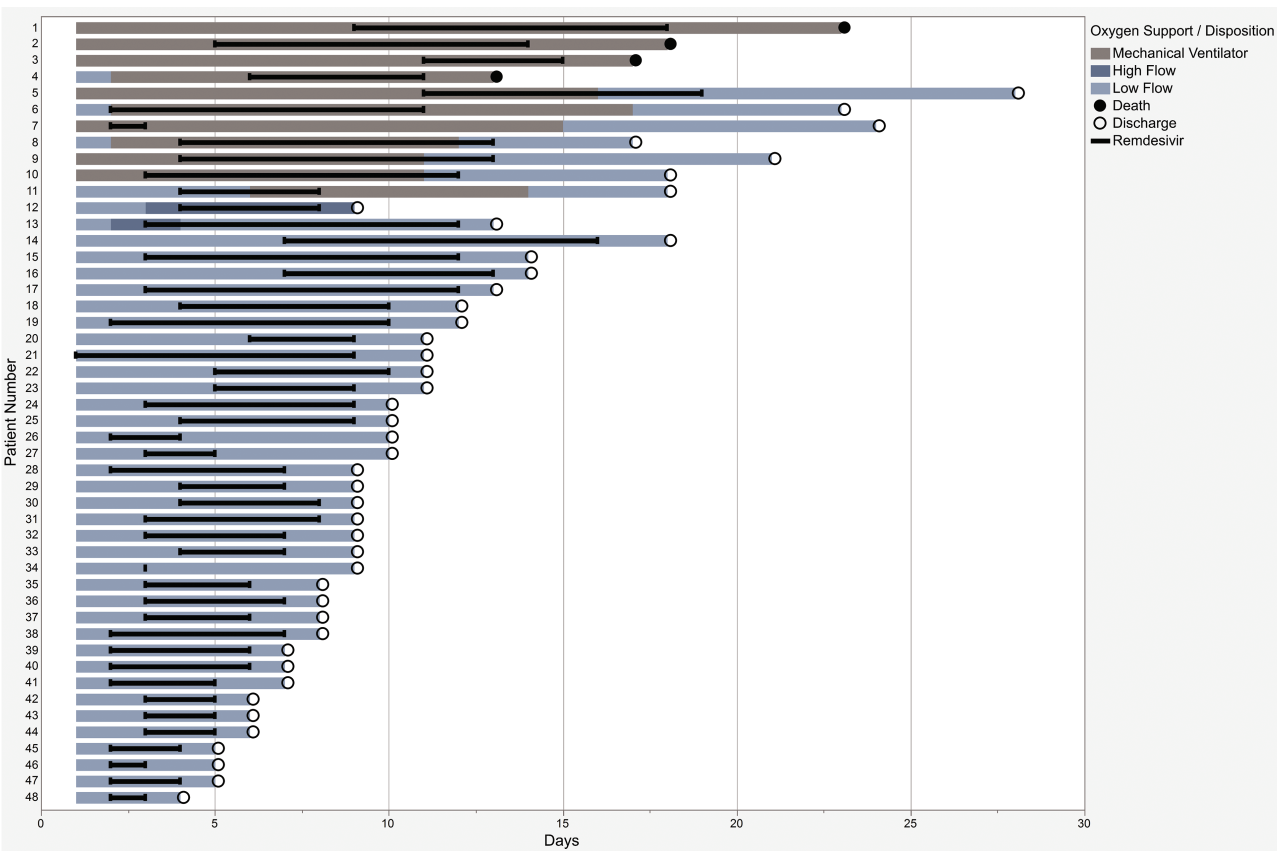


**Figure 2.** Changes in oxygen support from admission to discharge or death among hospitalized adults administered remdesivir. Day 1 was the day of hospital admission for patients administered remdesivir during hospitalization for COVID-19. Level of oxygen support is shown based on chargemaster codes during hospitalization and discharge disposition is indicated by open (discharged) and closed (death) circles. Abbreviation: COVID-19, coronavirus disease 2019.

A population-based study has also provided estimates of phenotypical characteristics, as well as morbidity and mortality, among patients who are part of the CDC's COVID-NET surveillance system [8].

A major strength of the current analysis is that it describes characteristics of hospitalized patients, including demographics, comorbidities, outcomes, and current treatments utilized during hospitalization, in a large sample size derived from both teaching and nonteaching hospitals across the United States. Furthermore, almost all patients (94.7%) in the current study had known outcomes derived from their entire hospitalization, in contrast to earlier reports [15].

In this study, death among patients hospitalized with COVID-19 infection was highly associated with mechanical ventilation during hospitalization. Survival for hospitalized patients with a known disposition was 77.4% overall, and was as high as 87.7% for patients who never received mechanical ventilation. Among the 1901 patients with known outcomes who received mechanical ventilation, only 27.1% were discharged alive.

Interestingly, those on mechanical ventilation within 24 hours of admission had better outcomes, compared to those placed on mechanical ventilation later in their hospitalization. Although this may solely reflect ascertainment bias, whereby some patients presented for admission later in the course of their illness, it could also suggest that some patients benefit from early intubation, while in others a more slowly progressive illness, culminating in a need for mechanical ventilation, has a worse prognosis. Thus, any intervention that could shorten the duration of illness may have an impact on survival. Furthermore, the impact of ventilation on outcomes remains controversial, and evolving efforts to avoid mechanical ventilation with interventions such as proning need further evaluation [17].

Independent risk factors were also associated with mechanical ventilation and death during hospitalization. Males >60 years old were more likely to receive mechanical ventilation and had a higher mortality rate than younger females. However, despite the suggestion that outcomes are worse for older patients, 8.4% of hospitalized patients below the age of 60 also succumbed to COVID-19, and therefore younger cases should be carefully managed as well. Multivariable logistic models that adjusted for other risk factors and demographic characteristics demonstrated that patients with comorbid obesity, chronic kidney disease, and cardiovascular disease were also more likely to receive mechanical ventilation, compared to those without a history of these comorbid conditions. The same risk factors, except obesity, were implicated in the risk of death during hospitalization. In contrast, hypertension, a history of smoking, and history of pulmonary disease were associated with lower risks of needing mechanical ventilation and/or lower risks of mortality. Though data are conflicting in the literature, other analyses have found a similar lack of an association between severity of disease and smoking or pulmonary disease; it is also possible that the absence of reliable smoking histories may confound these analyses [5, 18, 19].

Geographic location was associated with both an increased risk of receiving mechanical ventilation and with mortality. Patients living in the Midwest, West, and Southern regions of the United States were more likely to be discharged alive when compared to patients living in the Northeast. Several epidemiologic factors may contribute to the geographic variability in COVID-19–related mortality rates. In 2014, the prevalences of adults living with multiple chronic health conditions were higher in the Northeast and Southeast, compared to other regions of the United States [20]. Although adjustments were made for age, sex, and comorbid disease at admission, the underlying baseline rate of chronic disease among patients hospitalized for COVID-19 may have been lower in the Central and Western regions. Furthermore, as of 20 April 2020, the cumulative incidence of confirmed COVID infection in New Jersey, New York, and New York City was 4 to 9 times that of the national average [21]. Thus, stress on health-care resources due to a higher population density and differences in severity of illness at time of admission may have also contributed to the relative increased rate of mortality in the Northeast [22].

Remdesivir, a nucleoside analogue with in vitro activity against SARS-CoV-2, has recently been approved under an emergency use authorization to treat COVID-19 [11]. In a compassionate use study, the mortality rate of 34 patients on a mechanical ventilator treated with remdesivir was only 18% [23]. In the current cohort, 48 patients were treated with remdesivir with only 4 deaths overall, occurring exclusively among the 11 patients who received mechanical ventilation (36.4%). Preliminary results from a placebo-controlled trial indicated that remdesivir shortened the course of illness, with a possible trend toward improved mortality [24].

Hydroxychloroquine has also demonstrated in vitro activity against SARS-CoV-2 [12, 13, 25]. Despite the controversy regarding its effectiveness, this drug has been prescribed widely in patients with COVID-19 [26, 27]. In the current cohort, unadjusted mortality rates were higher among patients receiving hydroxychloroquine. These results must be interpreted with caution, as outcomes were confounded by higher rates of comorbid conditions and disease severity among those treated with hydroxychloroquine. However, a recent randomized study of hospitalized COVID-19 patients treated with hydroxychloroquine failed to demonstrate a therapeutic benefit with this agent [28].

This study has several limitations. There is a high level of confidence in the validity of diagnosis of COVID-19; all patients had ICD-10 inpatient codes associated with COVID-19, and 77.3% of the population was assigned a specific confirmatory code for COVID-19 (U07.1). Nevertheless, variables were created using billing and ICD-10 coding from clinical documentation contained in the patient medical record and Official

Coding Guidelines set forth by the Centers for Medicare and Medicaid Services, and there is the potential for the misclassification and underrepresentation of comorbid conditions, treatments, procedures, and therapies. This study also could not capture the patient's severity of illness at the time of admission based upon vital signs, oxygen saturation, or laboratory results, which were not available within the chargemaster data set.

Recent studies have indicated that African American patients are disproportionately infected by COVID-19 and have worse outcomes than other racial groups [29]. The hospital chargemaster data did not include race category and, therefore, this could not be evaluated. However, the current data did provide robust information on comorbid conditions, several of which were identified to impact outcomes in COVID-19 that are also well established as being overrepresented in Black individuals [30, 31]. This may have contributed to the impact on COVID-19 outcomes in this population.

This study greatly contributes to understanding the natural course of COVID-19 infection, by describing characteristics and outcomes of patients with COVID-19 hospitalized throughout the United States. It identified categories of patients at the greatest risk for poor outcomes, which should be used to prioritize prevention and treatment strategies in the future.

### Supplementary Data

Supplementary materials are available at *Clinical 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.

### Notes

***Disclaimer.*** TARGET was responsible for the design and conduct of the study; collection, management, analysis and interpretation of the data; preparation, review and approval of the manuscript; and decision to submit the manuscript for publication. The data were derived from a commercial insurance claims database that requires a data sharing agreement and data license for access.

***Financial support.*** This work was supported by TARGET PharmaSolutions Inc., and funding for the initial data acquisition was provided by Gilead.

***Potential conflicts of interest.*** M. W. F. receives personal fees from TARGET PharmaSolutions Inc. as an independent contractor consultant, serving in the role of Chief Medical Officer; is a stockholder in TARGET PharmaSolutions Inc.; and has received grants paid to the University of North Carolina from Gilead, Abbvie, the National Institutes of Health, and Merck, outside the submitted work. A. R. M., J. M. C., S. E. W., B. M. H., R. C. Z., and K. B. are employees of TARGET PharmaSolutions Inc. S. E. is President of Elliott Health Information Pros Inc. and has received consulting fees from TARGET PharmaSolutions Inc. R. S. B. has received grants and consulting fees from Gilead. K. R. R. has received grants paid to their institution from AbbVie, Gilead, Bristol Myers Squibb (BMS), Intercept, Conatus, Exact Sciences, Mallinckrodt, Grifols, and Merck; institutional grants to their institution from TARGET-hepatocellular carcinoma (HCC), TARGET-nonalcoholic steatohepatitis (NASH), and hepatitis C virus (HCV)-TARGET; and personal ad hoc advisory board fees from AbbVie, Gilead, Merck, BMS, Spark Therapeutics, Dova, Shionogi, and Mallinckrodt. C. L. has received research funding from Gilead, Pfizer, and Lilly; and institutional grants from TARGET-HCC, TARGET-NASH and HCV-TARGET. 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.

### References

1. Gorbalenya AE, Baker SC, Baric RS, et al. The species *Severe acute respiratory syndrome-related coronavirus*: classifying 2019-nCoV and naming it SARS-CoV-2. Nat Microbiol **2020**; 5:536–44.
2. Ghebreyesus TA. Director-general's remarks at the media briefing on 2019-nCoV on 11 February 2020. Available at: https://www.who.int/dg/speeches/detail/who-director-general-s-remarks-at-the-media-briefing-on-2019-ncov-on-11-february-2020. Accessed 25 May 2020.
3. World Health Organization. Coronavirus disease 2019 (COVID-19) situation report–198, 2020.
4. Holshue ML, DeBolt C, Lindquist S, et al; Washington State 2019 Novel Coronavirus (2019-nCoV) Case Investigation Team. First case of 2019 novel coronavirus in the United States. N Engl J Med **2020**; 382:929–36.
5. Zhou F, Yu T, Du R, et al. Clinical course and risk factors for mortality of adult inpatients with COVID-19 in Wuhan, China: a retrospective cohort study. Lancet **2020**; 395:1054–62.
6. Wang D, Hu B, Hu C, et al. Clinical characteristics of 138 hospitalized patients with 2019 novel coronavirus-infected pneumonia in Wuhan, China. JAMA **2020**; 323:1061–9.
7. Zhao X, Zhang B, Li P, et al. Incidence, clinical characteristics and prognostic factor of patients with COVID-19: a systematic review and meta-analysis. medRxiv **2020** [Preprint]. March 20, 2020 [cited 2020 May 25]. Available from: https://doi.org/10.1101/2020.03.17.20037572.
8. 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.
9. Schneeweiss S, Avorn J. A review of uses of health care utilization databases for epidemiologic research on therapeutics. J Clin Epidemiol **2005**; 58:323–37.
10. US Department of Commerce Economics and Statistics Administration, US Census Bureau Geography Division. Retrieved May 25, 2020.
11. Food and Drug Administration. Coronavirus (COVID-19) update: FDA issues emergency use authorization for potential COVID-19 treatment. Silver Spring, MD: Food and Drug Administration Office of Media Affairs, **2020**.
12. Wang M, Cao R, Zhang L, et al. Remdesivir and chloroquine effectively inhibit the recently emerged novel coronavirus (2019-nCoV) in vitro. Cell Res **2020**; 30:269–71.
13. Liu J, Cao R, Xu M, et al. Hydroxychloroquine, a less toxic derivative of chloroquine, is effective in inhibiting SARS-CoV-2 infection in vitro. Cell Discov **2020**; 6:16:1–4.
14. 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.
15. Richardson S, Hirsch JS, Narasimhan M, et al. Presenting characteristics, comorbidities, and outcomes among 5700 patients hospitalized with COVID-19 in the New York City area. JAMA **2020**; 323:2052–9.
16. Geleris J, Sun Y, Platt J, et al. Observational study of hydroxychloroquine in hospitalized patients with COVID-19. N Engl J Med **2020**; 382:2411–8.
17. Caputo ND, Strayer RJ, Levitan R. Early self-proning in awake, non-intubated patients in the emergency department: a single ED's experience during the COVID-19 pandemic. Acad Emerg Med **2020**; 27:375–8.
18. Lippi G, Henry BM. Active smoking is not associated with severity of coronavirus disease 2019 (COVID-19). Eur J Intern Med **2020**; 75:107–8.
19. Zhao Q, Meng M, Kumar R, et al. The impact of COPD and smoking history on the severity of COVID-19: a systemic review and meta-analysis. J Med Virol **2020** [Preprint]. April 15, 2020 [cited 2020 May 25]. Available from: https://doi.org/10.1002/jmv.25889.
20. Ward BW, Black LI. State and regional prevalence of diagnosed multiple chronic conditions among adults aged ≥18 years–United States, 2014. MMWR Morb Mortal Wkly Rep **2016**; 65:735–8.
21. Geographic differences in COVID-19 cases, deaths, and incidence–United States, February 12-April 7, 2020. MMWR Morb Mortal Wkly Rep **2020**; 69:465–71.
22. Brufsky A. Distinct viral clades of SARS-CoV-2: implications for modeling of viral spread. J Med Virol **2020**; 92:1386–90.
23. Grein J, Myers RP, Brainard D. Compassionate use of remdesivir in COVID-19. Reply. N Engl J Med **2020**; 382:e101.
24. Beigel JH, Tomashek KM, Dodd LE, et al. Remdesivir for the treatment of COVID-19—preliminary report. New Eng J Med **2020** [Preprint]. May 22, 2020 [cited 2020 May 25]. Available from: https://doi.org/10.1056/NEJMoa2007764.

25. Andreani J, Le Bideau M, Duflot I, et al. In vitro testing of combined hydroxychloroquine and azithromycin on SARS-CoV-2 shows synergistic effect. Microb Pathog **2020**; 145:1–4.
26. Gautret P, Lagier JC, Parola P, et al. Hydroxychloroquine and azithromycin as a treatment of COVID-19: results of an open-label non-randomized clinical trial. Int J Antimicrob Agents **2020**; 56:1–21.
27. Pastick KA, Okafor EC, Wang F, et al. Review: hydroxychloroquine and chloroquine for treatment of SARS-CoV-2 (COVID-19). Open Forum Infect Dis **2020**; 7:1–27.
28. Cavalcanti AB, Zampieri FG, Rosa RG, et al. Hydroxychloroquine with or without azithromycin in mild-to-moderate COVID-19. New Eng J Med **2020** [Preprint]. July 23, 2020. Available from: https://doi.org/10.1056/nejmoa2019014.
29. Yancy CW. COVID-19 and African Americans. JAMA **2020**; 323:1891–2.
30. Dias JP, Shardell M, Golden SH, Ahima RS, Crews DC. Racial/ethnic trends in prevalence of diabetic kidney disease in the United States. Kidney Int Rep **2019**; 4:334–7.
31. Hackler E 3rd, Lew J, Gore MO, et al. Racial differences in cardiovascular biomarkers in the general population. J Am Heart Assoc **2019**; 8:e012729.