Patient Characteristics and Outcomes of 11,721 Patients with COVID-19 Hospitalized Across the United States

Michael W. Fried, MD TARGET PharmaSolutions, Inc., Durham, NC, USA

Julie M. Crawford, MD, TARGET PharmaSolutions, Inc., Durham, NC, USA

Andrea R. Mospan, PhD, TARGET PharmaSolutions, Inc., Durham, NC, USA

Stephanie E. Watkins, PhD, TARGET PharmaSolutions, Inc., Durham, NC, USA

Breda Munoz Hernandez, PhD, TARGET PharmaSolutions, Inc., Durham, NC, USA

Richard C. Zink, PhD, TARGET PharmaSolutions, Inc., Durham, NC, USA

Sherry Elliott, Elliott Health Information Pros, Inc., Cary, NC, USA

Kyle Burleson, TARGET PharmaSolutions, Inc., Durham, NC, USA

Charles Landis, MD, PhD, Liver Care and Transplantation Services at University of Washington Medical Center, Seattle, WA, USA

K. Rajender Reddy, MD, Department of Medicine, University of Pennsylvania, Philadelphia, PA, USA

Robert S. Brown, Jr., MD, MPH, Department of Medicine, Division of Gastroenterology and Hepatology, Weill Cornell Medicine Center for Liver Disease, New York, NY, USA

Corresponding author: Michael W. Fried, MD

Chief Medical Officer

TARGET PharmaSolutions

Email: mfried@targetpharmasolutions.com

Mobile: 919-622-5992

Address:

TARGET PharmaSolutions

2520 Meridian Pkwy, Ste 105
Durham, NC 27713

© The Author(s) 2020. Published by Oxford University Press for the Infectious Diseases Society of America. All rights reserved. For permissions, e-mail: journals.permissions@oup.com.

Accepted Manuscript

Summary: Of 11,721 patients hospitalized for COVID-19, male sex, older age, obesity, region, chronic kidney disease and cardiovascular disease were associated with need for mechanical ventilation and all, except obesity, were associated with increased mortality. This information may inform COVID-19 management.

Accepted Manuscript

Abstract

BACKGROUND**:** As COVID-19 disseminates throughout the US, a better understanding of 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 February 15 and April 20, 2020 were assessed. Clinical course from admission through hospitalization 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 1,967 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 preexisting cardiovascular disease were associated with an increased odds of mechanical ventilation. All aforementioned risk factors, with the exception of obesity, were associated with an increased odds of death (all $p < 0.001$). Many patients received investigational medications for treatment of COVID-19, including 48 patients on remdesivir and 4,232 on hydroxychloroquine.

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

Key Words: SARS-CoV-2, COVID-19, observational study, hydroxychloroquine, remdesivir

Accepted Manuscript

Introduction

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 (US), the first case of COVID-19 was reported on January 20, 2020 in Washington State.[4] As of August 5, 2020, there have been over 4.6 million confirmed cases and 154,952 deaths attributed to COVID-19 in the US.[3]

In early reports in China and the US, 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-NET surveillance system, 89% of patients hospitalized in March, 2020 with laboratory confirmed infection had at least one underlying comorbid condition.[8]

As the COVID-19 pandemic is rapidly evolving, population-based studies in the US evaluating patient characteristics associated with hospitalization and survival are limited. Previous studies have examined 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 treatment of COVID-19, an understanding of 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 patient characteristics associated with morbidity and mortality among patients hospitalized in the US.

Accepted Manuscript

Methods

Data Source

Deidentified hospital claims data from the hospital chargemaster, a comprehensive list of all billable products, procedures and services provided to inpatients, were acquired from a commercially available source representing adults receiving inpatient care between February 15 and April 20, 2020 at 245 hospitals across 38 states in the US. This research was determined to be IRB exempt as it does not constitute human subject research requiring IRB review based on federal regulation 45 CFR 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 ICD-10 codes indicating presence of a chronic condition at the time of admission and from hospital encounters within 12 months up to the date of admission. 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 claims data (**Supplemental Table 1**).[9]

Characteristics of Hospitalization

The needs for oxygen supplementation and mechanical ventilation were captured at admission and over the course of the patient's hospitalization (**Supplemental 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

Accepted Manuscript

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. ICU level of care and use of putative therapies, including select medications under investigation for COVID-19, were also captured.

Statistical Analysis

Differences in proportions and means of demographics, comorbidities, and characteristics of the patients' hospitalization were compared by need for mechanical ventilation using a chi-squared test and Kruskall-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 association between demographic and comorbid disease at admission and the odds of 1) death and 2) the need for mechanical ventilation were estimated using multivariable logistic regression. Based on previous literature, the association of the following risk factors with morbidity and mortality was 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. Location of hospitals using regions defined by the US Census Bureau as Northeast, Midwest, South, and West, was also included in the models to explore regional disparities in outcomes.[10]

All variables were entered as either dichotomous or categorical variables. Age was categorized into the following groups: 18-40 years, 41-60 years, >60 years. Insurance status was categorized into a four-level variable: Commercial, Medicaid, Medicare, Other. Patient

Accepted Manuscript

history of select co-morbid diseases were modeled as dichotomous variables. Odds ratios and corresponding 95% confidence intervals were provided for each risk factor.

Results

Demographics and Comorbid Disease

The study population included 11,721 patients ≥ 18 years admitted between February 15 and April 20, 2020 across 245 hospitals with an ICD-10 code indicating COVID-19 infection, including 9,057 (77%) with the confirmatory ICD-10 code released after April 1, 2020. Patient demographics and comorbid conditions are shown in **Table 1**. Sixty percent of hospitalized patients 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 patients, diabetes in 27.8%, cardiovascular disease in 18.6%, obesity in 16.1%, and chronic kidney disease in 12.2% of this cohort. History of pulmonary disease was present for 14.8% of patients, and 16.4% of patients had a history of smoking (N=1,922). One hundred and sixty-seven patients were pregnant at admission. 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 US. In terms of insurance status more patients were on Medicare (45.3%) compared to commercial insurance (26.6%), Medicaid (12.8%) , and other or unknown insurance status (15.3%) (**Table 1**).

Accepted Manuscript

Characteristics of Hospitalization

Median duration of hospitalization for all patients from admission to either discharge or death was 7.0 days (range: 2.0-60.0 days). Six hundred and seventeen (5.3%) patients were still hospitalized at the time of the data cutoff. 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 7,570 patients (64.6%), high-flow O2 in 643 patients (5.5%) and mechanical ventilation was required in 1,967 patients (16.8%). There were 1,541 (13.1%) patients who were categorized as having not received oxygen support. Twenty percent of patients (N=2,336) received ICU level of care with a median length of ICU stay of 5 days (range: 1.0-60.0 days).

Most hospitalized patients were discharged alive (73.3%). Twenty one percent of patients died, with a median length of stay of 8.0 days (range: 2.0-60.0 days) (**Table 2**). Among 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 ($p < 0.0001$; 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

Accepted Manuscript

ventilation over the course of their hospitalization were more likely to be male (63.9% vs 51.3%, p<0.0001) and over the age of 60 years (67.3% vs 58.4%, p<0.0001). History of chronic kidney disease (15.2% vs 11.6%, p<0.0001), cardiovascular disease (22.6% vs 17.8%, p<0.001), diabetes (31.7% vs 27.0%, p<0.0001), and obesity (18.3% vs 15.7%, p<0.0042) were more frequent among those who required mechanical ventilation compared to 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- , high-flow or no oxygen supplementation (11.0 vs. 7.0 days; p<0.0001). 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<0.001) **(Table 2).** An increasing trend was observed among patients requiring mechanical ventilation with 5.6%, 27.1%, and 67.3% using mechanical ventilation as age groups increased (18-40, 41-60 and >60 years, respectively (p<0.0001) (**Table 1**).

Risk factors associated with mechanical ventilation include male sex, advancing age (>60 years) and those between 41-60 years, obesity, geographic region, 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 1a)**.

Increased odds of mortality were associated with advancing age, presence of chronic kidney disease, cardiovascular disease, male sex, non-commercial insurance status, and Northeast

Accepted Manuscript

region. In an adjusted multivariable logistic model, the odds of death among patients over the age of 60 years was 7.2 (95% CI: 5.4,9.7) times that of patients between 18 and 40 years. Patients between the age of 41 and 60 were also at an increased risk compared to those age 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. Odds of death were lower in patients with a history of hypertension, pulmonary disease, or smoking (**Figure 1b**).

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 compared to patients whose highest level of oxygen supplementation was low- or high-flow or no oxygen (**Supplemental Figure 1)**. The magnitude of the association of ventilatory status with mortality was also dependent on 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) (**Supplemental 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

Accepted Manuscript

discharged. Changes in 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); 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 a mortality rate 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 (**Supplemental Table 2**).

Over 4,200 patients (36.1%) were treated with hydroxychloroquine, a medication approved for various rheumatologic diseases and 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 compared to those who did not receive hydroxychloroquine (24.9% vs 12.2%). The unadjusted mortality rate for patients treated with hydroxychloroquine was 24.8%, compared to 19.6% among those who did not receive hydroxychloroquine (**Supplemental Table 3**).

Accepted Manuscript

Discussion

The epidemiology, risk factors, and outcomes of patients with COVID-19 are under intense study and best management 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 US and often included data ascertained from single hospital systems.[5,14-16] 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 teaching and non-teaching hospitals across the US. 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 1,901 patients with known outcomes receiving mechanical ventilation, only 27.1% were discharged alive.

Interestingly, those on mechanical ventilation within 24 hours of admission had a better outcome compared to those placed on mechanical ventilation later in their hospitalization. Although this may solely reflect ascertainment bias, whereby some patients presented for

Accepted Manuscript

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 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 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 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 a lower risk of needing mechanical ventilation and/or lower risk 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]

Accepted Manuscript

Geographic location was associated with both an increased risk of receiving mechanical ventilation as well as mortality. Patients living in the Midwest, West, and Southern regions of the US were more likely to be discharged alive compared to patients living in the Northeast. Several epidemiologic factors may contribute to the geographic variability in COVID-related mortality rates. In 2014, the prevalence of adults living with multiple chronic health conditions was higher in the North and South East compared to other regions of the US.[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 April 20th 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 healthcare 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 have been 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]

Accepted Manuscript

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, recent randomized study of hospitalized COVID-19 patients treated with hydroxychloroquine failed to demonstrate 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 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 dataset.

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

Accepted Manuscript

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 over-represented 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 US. It identified categories of patients at greatest risk for poor outcomes, which should be used to prioritize prevention and treatment strategies in the future.

Accepted Manuscript

Acknowledgements:

This work was supported by TARGET PharmaSolutions, Inc. TARGET is 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. Funding for initial data acquisition was provided by Gilead.

Potential Conflicts of Interest:

MWF: Receives personal fees from TARGET PharmaSolutions, Inc. as an independent contractor consultant, serving in the role of Chief Medical Officer. He is a stockholder in TARGET PharmaSolutions, Inc. He reports grants paid to the University of North Carolina from Gilead, Abbvie, National Institutes of Health and Merck, outside the submitted work.

AM, JC, SW, BMH, RCZ and KB: Employees of TARGET PharmaSolutions, Inc.

SE: President of Elliott Health Information Pros, Inc. and received consulting fees from TARGET PharmaSolutions, Inc.

RB: Grants and consulting from Gilead.

KRR: Grants paid to the institution from AbbVie, Gilead, BMS, Intercept, Conatus, Exact Sciences, Mallinckrodt, Grifols, and Merck. Institutional grants to the institution from TARGET-HCC, TARGET-NASH and HCV-TARGET. Personal ad hoc advisory board fees from AbbVie, Gilead, Merck, BMS, Spark Therapeutics, Dova, Shionogi, and Mallinckrodt.

Accepted Manuscript

CL: Research funding from Gilead, Pfizer, and Lilly. Institutional grants from TARGET-HCC, TARGET-NASH and HCV-TARGET.

Accepted Manuscript

References

1. Severe acute respiratory syndrome-related coronavirus: The species and its viruses – a statement of the Coronavirus Study Group. 2020, February 11. at https://www.biorxiv.org/content/10.1101/2020.02.07.937862v1.)
2. Director-General's remarks at the media briefing on 2019-nCoV on 11 February 2020. 2020. at https://www.who.int/dg/speeches/detail/who-director-general-s-remarks-at-the-media-briefing-on-2019-ncov-on-11-february-2020.)
3. WHO. Coronavirus disease 2019 (COVID-19) situation report–198.
4. Holshue ML, DeBolt C, Lindquist S, et al. 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.
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 2020:2020.03.17.20037572.
8. Garg S KL, 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. U.S. Department of Commerce Economics and Statistics Administration U.S. Census Bureau Geography Division.
11. FDA. Coronavirus (COVID-19) Update: FDA Issues Emergency Use Authorization for Potential COVID-19 Treatment. FDA News Release: FDA 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 Research 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.
14. Goyal P, Choi JJ, Pinheiro LC, et al. Clinical Characteristics of Covid-19 in New York City. N Engl J Med 2020.
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.
16. Geleris J, Sun Y, Platt J, et al. Observational Study of Hydroxychloroquine in Hospitalized Patients with Covid-19. N Engl J Med 2020.
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.
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. Team CC-R. 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.
23. Grein J, Ohmagari N, Shin D, et al. Compassionate Use of Remdesivir for Patients with Severe Covid-19. N Engl J Med 2020.

Accepted Manuscript

24. Beigel JH, Tomashek KM, Dodd LE, et al. Remdesivir for the Treatment of Covid-19 — Preliminary Report. New England Journal of Medicine 2020.
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;145:104228.
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 2020:105949.
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:ofaa130.
28. Cavalcanti AB, Zampieri FG, Rosa RG, et al. Hydroxychloroquine with or without Azithromycin in Mild-to-Moderate Covid-19. New England Journal of Medicine 2020.
29. Yancy CW. COVID-19 and African Americans. JAMA 2020.
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.

Accepted Manuscript

Table 1. Characteristics of adult patients hospitalized for COVID-19

Characteristics	Mechanical ventilation needs: Needed MV [a] (N=1967)	Mechanical ventilation needs: Did Not need MV (N=9754)	Total (N=11721)	P-Value [b]
Demographics				
Age group, n (%)				<.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)	
Non-Teaching	805 (40.9)	3534 (36.2)	4339 (37.0)	
Census Region, n (%)				0.0009
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)	0.0042
History of HTN, n (%)	941 (47.8)	4534 (46.5)	5475 (46.7)	0.2716
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)	0.0365
History of Pulmonary disease, n (%)	275 (14.0)	1462 (15.0)	1737 (14.8)	0.2510
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)	0.1035
History of smoking, n (%)	293 (14.9)	1629 (16.7)	1922 (16.4)	0.0486
History of Liver disease, n (%)	34 (1.7)	113 (1.2)	147 (1.3)	0.0382
History of solid organ transplant, n (%)	12 (0.6)	84 (0.9)	96 (0.8)	0.2597
History of BMT/SCT, n (%)	2 (0.1)	16 (0.2)	18 (0.2)	0.5194
History of non-skin cancer malignancy, n (%)	129 (6.6)	713 (7.3)	842 (7.2)	0.2390
History of Peripheral Vascular Disease, n (%)	64 (3.3)	258 (2.6)	322 (2.7)	0.1320
History of HIV/AIDS, n (%)	17 (0.9)	94 (1.0)	111 (0.9)	0.6778
History of autoimmune (RA/SLE), n (%)	21 (1.1)	147 (1.5)	168 (1.4)	0.1347
Inflammatory bowel disease, n (%)	4 (0.2)	28 (0.3)	32 (0.3)	0.5163
Current pregnancy, n (%)	5 (0.3)	162 (1.7)	167 (1.4)	<.0001

Accepted Manuscript

BMT = bone marrow transplant; MV = mechanical ventilation; RA = rheumatoid arthritis; SCT = stem cell transplant; SLE =systemic lupus erythematosus
[a] Includes 6 patients on ECMO.

[b] Chi-Square or Fisher Exact test p-values reported comparing those who needed mechanical ventilation 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.

Accepted Manuscript

Table 2. Characteristics of hospitalization among adult patients hospitalized with COVID-19

Characteristics	Mechanical ventilation needs: Needed MV (N=1967 [a])	Mechanical ventilation needs: Did Not need MV (N=9754)	Total (N=11721)	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 24H 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)	

Accepted Manuscript

Table 2. Characteristics of hospitalization among adult patients hospitalized with COVID-19

Characteristics	Mechanical ventilation needs		Total	P-Value [b]
	Needed MV (N=1967 [a])	Did Not need MV (N=9754)	Total (N=11721)	
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 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 24H of admission, n (%)	1059 (53.8)	5077 (52.1)	6136 (52.4)	0.1475
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 (0.6)	37 (0.4)	48 (0.4)	0.2544
Other treatment [f] n (%)	228 (11.6)	137 (1.4)	365 (3.1)	<.0001

Accepted Manuscript

Table 2. Characteristics of hospitalization among adult patients hospitalized with COVID-19

Characteristics	Mechanical ventilation needs		Total (N=11721)	P-Value [b]
	Needed MV (N=1967 [a])	Did Not need MV (N=9754)		

ECMO = extracorporeal membrane oxygenation; ICU = intensive care unit; MV = mechanical ventilation

[a] Six of these patients were on ECMO.

[b] Chi-Square, Fisher Exact test or Kruskal Wallis test p-values reported comparing those who needed mechanical ventilation 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] Thirty-nine patients had indeterminant admission status when MV was initiated and were assumed to have been put on MV on day 1.

[e] Three of these patients were on ECMO.

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

Accepted Manuscript

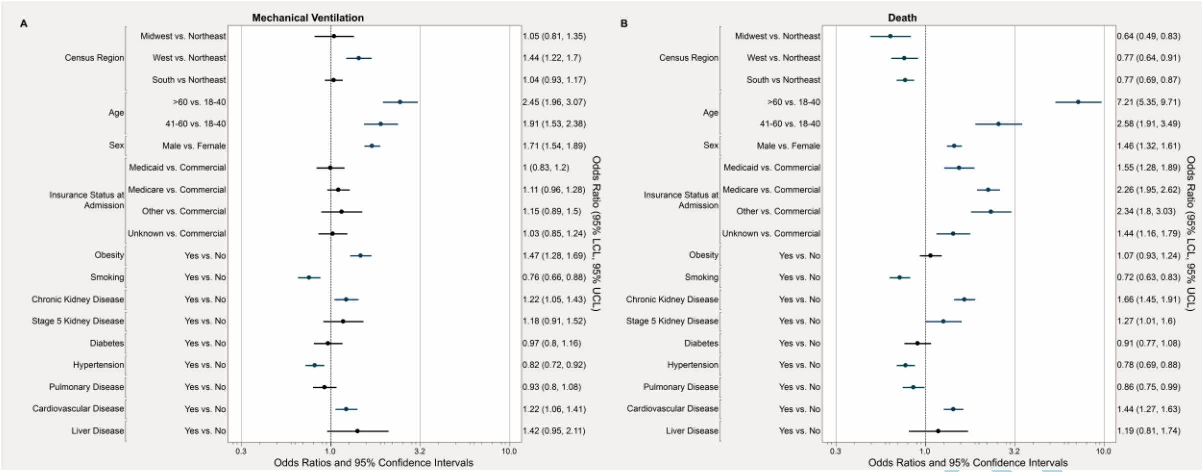
FIGURE LEGENDS:

Figure 1. Odds ratios and 95% confidence intervals from multivariable logistic regression models for mechanical ventilation (A, left) or death (B, right) for adult hospitalized patients with COVID-19. Odds ratio estimates are adjusted for all other variables in the model.

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.

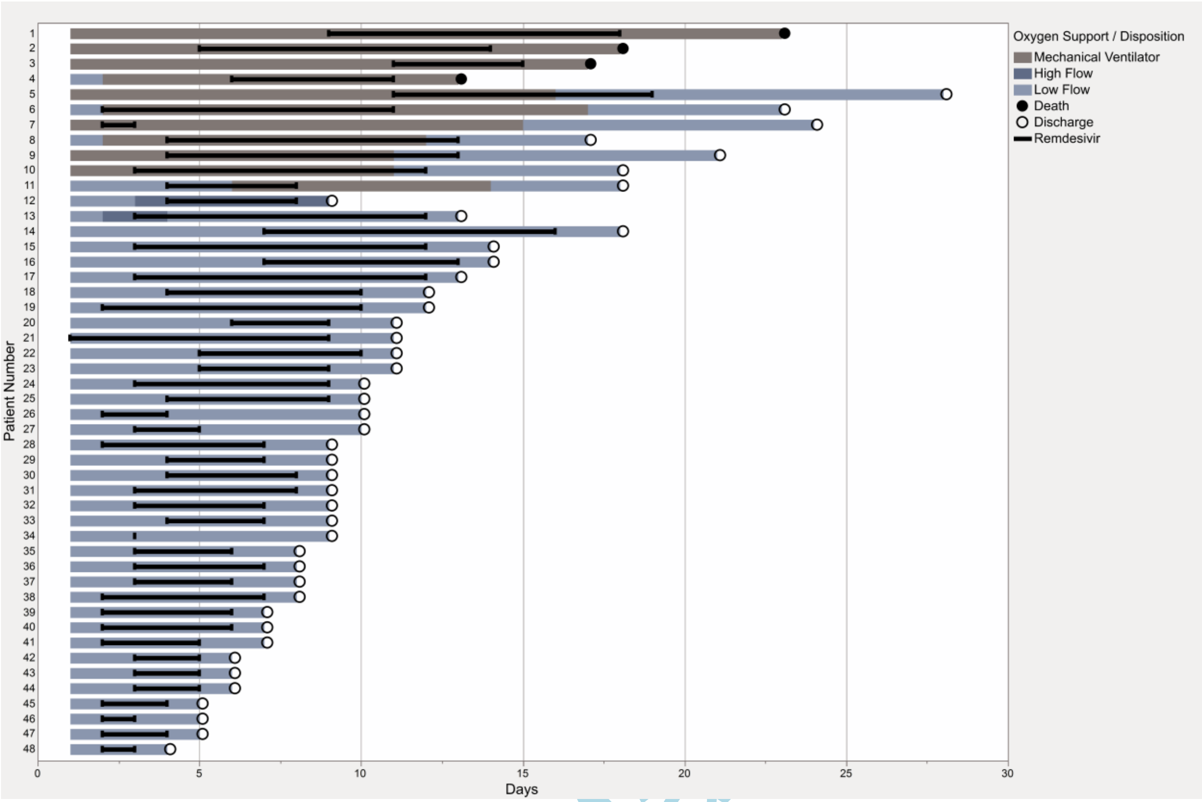
Accepted Manuscript

Figure 1



Accepted Manuscript

Figure 2



Accepted Ma