1 **Interim Analysis of Risk Factors for Severe Outcomes among a Cohort of Hospitalized Adults Identified**
2 **through the U.S. Coronavirus Disease 2019 (COVID-19)-Associated Hospitalization Surveillance**
3 **Network (COVID-NET)**
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48   **ABSTRACT**

49   **Background:** As of May 15, 2020, the United States has reported the greatest number of coronavirus

50   disease 2019 (COVID-19) cases and deaths globally.

51   **Objective:** To describe risk factors for severe outcomes among adults hospitalized with COVID-19.

52   **Design:** Cohort study of patients identified through the Coronavirus Disease 2019-Associated

53   Hospitalization Surveillance Network.

54   **Setting:** 154 acute care hospitals in 74 counties in 13 states.

55   **Patients:** 2491 patients hospitalized with laboratory-confirmed COVID-19 during March 1–May 2, 2020.

56   **Measurements:** Age, sex, race/ethnicity, and underlying medical conditions.

57   **Results:** Ninety-two percent of patients had ≥1 underlying condition; 32% required intensive care unit

58   (ICU) admission; 19% invasive mechanical ventilation; 15% vasopressors; and 17% died during

59   hospitalization. Independent factors associated with ICU admission included ages 50-64, 65-74, 75-84

60   and ≥85 years versus 18-39 years (adjusted risk ratio (aRR) 1.53, 1.65, 1.84 and 1.43, respectively); male

61   sex (aRR 1.34); obesity (aRR 1.31); immunosuppression (aRR 1.29); and diabetes (aRR 1.13).

62   Independent factors associated with in-hospital mortality included ages 50-64, 65-74, 75-84 and ≥85

63   years versus 18-39 years (aRR 3.11, 5.77, 7.67 and 10.98, respectively); male sex (aRR 1.30);

64   immunosuppression (aRR 1.39); renal disease (aRR 1.33); chronic lung disease (aRR 1.31); cardiovascular

65   disease (aRR 1.28); neurologic disorders (aRR 1.25); and diabetes (aRR 1.19). Race/ethnicity was not

66   associated with either ICU admission or death.

67   **Limitation:** Data were limited to patients who were discharged or died in-hospital and had complete

68   chart abstractions; patients who were still hospitalized or did not have accessible medical records were

69   excluded.

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70   **Conclusion:** In-hospital mortality for COVID-19 increased markedly with increasing age. These data help

71   to characterize persons at highest risk for severe COVID-19-associated outcomes and define target

72   groups for prevention and treatment strategies.

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Introduction

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80   In December 2019, an outbreak of a novel coronavirus disease, termed coronavirus disease-

81   2019 (COVID-19), was reported in China caused by a newly identified coronavirus, severe acute

82   respiratory syndrome coronavirus-2 (SARS-CoV-2). Since then, approximately 4.5 million cases of

83   COVID-19 have been reported globally (1). As of May 15, approximately 1.4 million cases, including

84   nearly 86,000 deaths, have been reported in the United States, and case counts continue to rise (1) with

85   evidence of widespread community transmission (2).

86   Previous reports from China, Italy, and New York City have demonstrated that hospitalized

87   patients are generally older and have underlying medical conditions, such as hypertension and diabetes

88   (3-5). These studies have also found that older patients and those with certain underlying medical

89   conditions like diabetes were at higher risk for severe outcomes (3, 6, 7). Among cases reported to the

90   U.S. Centers for Disease Control and Prevention (CDC) from local and state health departments, the

91   prevalence of underlying medical conditions increased as severity of infections increased (8, 9), although

92   findings were limited by missing or incomplete information. Questions remain about the independent

93   association of sex, race/ethnicity and specific underlying conditions with severe outcomes among

94   persons hospitalized with COVID-19, after adjusting for age and other important potential confounders.

95   Comprehensive data on U.S. patients with severe COVID-19 infections are needed to better

96   inform clinicians' understanding of groups at risk for poor outcomes and to inform current prevention

97   efforts and future interventions. We rapidly implemented population-based surveillance for laboratory-

98   confirmed COVID-19-associated hospitalizations, collecting clinical data from hospitalized patients in 154

99   hospitals in 13 states since March 1, 2020. In this interim analysis restricted to patients who were

100   discharged or died in-hospital and had completed medical chart abstractions, we describe the

101   characteristics of U.S. adults hospitalized with COVID-19 and assess risk factors for intensive care unit

102   (ICU) admission and in-hospital mortality.

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METHODS

Surveillance Overview

106   The Coronavirus Disease 2019-Associated Hospitalization Surveillance Network (COVID-NET) has

107   been previously described (10). Eligible COVID-19-associated hospitalizations occurred among persons

108   who (1) resided in a pre-defined surveillance catchment area; and (2) had a positive SARS-CoV-2 test

109   within 14 days prior to or during hospitalization. Hospitalization was defined as admission to an

110   inpatient ward for any length of time, an observation unit stay for ≥24 hours, or a combined stay in an

111   emergency department and observation unit for ≥24 hours.

112   COVID-NET surveillance occurs in acute care hospitals within 99 counties located in 14 states

113   (California, Colorado, Connecticut, Georgia, Iowa, Maryland, Michigan, Minnesota, New Mexico, New

114   York, Ohio, Oregon, Tennessee, and Utah), covering a catchment population of approximately 32 million

115   persons (~10% of the U.S. population). Although COVID-NET includes all age groups, for this analysis, we

116   excluded children <18 years of age due to small counts (n=101) and one surveillance site (Iowa) for

117   which medical chart abstractions were not conducted on identified cases. We also excluded patients

118   who were still hospitalized at the time of this analysis and all patients for whom medical chart

119   abstractions had not yet been completed. Because the COVID-19 pandemic limited the ability of

120   surveillance officers to access medical records at facilities, patients were more likely to be included in

121   this analysis if they were hospitalized at facilities that provided surveillance officers remote chart access,

122   participated in Health Information Exchanges, or were able to mail or fax records. COVID-NET

123   surveillance was initiated for cases with hospital admission on or after March 1, 2020.

124   Laboratory-confirmed COVID-19-associated hospitalizations were identified using laboratory

125   and reportable condition databases, hospital infection control databases, electronic medical records,

126 and/or review of hospital discharge records. Laboratory tests were ordered at the discretion of the

127 treating healthcare provider.

128 Medical chart reviews for demographic and clinical data were conducted by trained surveillance

129 officers using a standard case report form. Underlying medical conditions were categorized into major

130 groups (Appendix Table 1). Obesity and severe obesity were defined as a calculated body mass index

131 (BMI) ≥30 kg/m^2 and BMI ≥40 kg/m^2, respectively. Chest radiograph results were obtained from the

132 radiology reports and not from review of the original radiograph. We defined severe outcomes as either

133 ICU admission or in-hospital mortality. We hypothesized that increasing age and underlying medical

134 conditions would be associated with an increased risk of ICU admission and in-hospital mortality.

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136 ***Statistical Analysis***

137 After the exclusions noted above, we included adults hospitalized within 154 acute care

138 hospitals in 74 counties in 13 states with an admission date during March 1–May 2, 2020 who had either

139 been discharged from the hospital or died during hospitalization and had complete medical chart

140 abstractions. We calculated proportions using the number of patients with data available on each

141 characteristic as the denominator.

142 To construct multivariable models for ICU admission and in-hospital mortality, we first assessed

143 collinearity among underlying medical condition categories and outpatient use of ACE-inhibitors and

144 ARBs. We examined the association of demographic factors, underlying medical conditions, and

145 outpatient use of ACE-inhibitors and ARBs with ICU admission and in-hospital death using chi square

146 tests. Variables considered for inclusion in the final models included current or former smoker,

147 hypertension, obesity, diabetes, chronic lung disease (CLD), cardiovascular disease (CVD) (excluding

148 hypertension), neurologic disorders, renal disease, immunosuppression, gastrointestinal/liver disease,

149 hematologic conditions, rheumatologic/autoimmune conditions, and outpatient use of ACE-inhibitors or

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150   ARBs. All multivariable models included age categorized into the following groups (18–39, 40–49, 50–

151   64, 65–74, 75–84, and ≥85 years), sex, and race/ethnicity. Other variables with p-values <0.10 in

152   bivariate analyses were included in the multivariable analyses. Log-linked Poisson generalized

153   estimating equations regression with an exchangeable correlation matrix (11, 12), clustered by site, was

154   used to generate adjusted risk ratios (aRR), 95% confidence intervals (CI), and two-sided p-values for the

155   risk of ICU admission and in-hospital death. We also constructed separate multivariable models to

156   examine the association between the number of underlying medical conditions and ICU admission or in-

157   hospital death. Two-sided p-values <0.05 were considered statistically significant. All analyses were

158   performed using the SAS 9.4 software (SAS Institute Inc., Cary, NC, USA).

159   These data were collected as part of routine public health surveillance and determined to be

160   non-research by CDC. Participating sites obtained approval for the COVID-NET surveillance protocol

161   from their respective state and local IRBs, as required.

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163   ***Role of the Funding Source***

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168   **RESULTS**

169   A total of 16,318 hospitalized COVID-19 patients were reported to COVID-NET with an admission

170   date during March 1–May 2, 2020. After excluding 101 pediatric patients, 74 patients from Iowa where

171   detailed medical chart abstractions are not conducted, and 13,652 patients who were either still

172   hospitalized or did not yet have completed medical chart abstractions, 2,491 (15%) COVID-19-associated

173   hospitalized adults from 13 surveillance sites were included in this analysis (Figure 1). Patients came

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174   from 43% (154/357) of the acute care hospitals included in COVID-NET surveillance across the 13

175   surveillance sites (Appendix Table 2). The percentage of facilities contributing data out of the total

176   number of facilities by site ranged from 19% to 100%. The median age of included and excluded

177   patients (62 vs. 63 years, respectively) was similar (Appendix Table 3). The highest proportion of

178   patients included in this analysis were from Minnesota (20%), Tennessee (20%), New York (12%), and

179   Maryland (10%), and Connecticut (9%) (Appendix Table 3).

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181   **Characteristics of hospitalized patients with COVID-19**

182   Among the 2,491 hospitalized adults, median age was 62 years (interquartile range (IQR), 50–

183   75), and almost 75% were ≥50 years (Table 1). Forty-seven percent of patients (n=1178/2490) were

184   non-Hispanic whites, 30% non-Hispanic blacks (n=755/2490), and 12% Hispanics (n=306/2490). Nearly

185   one-third of patients were current or former smokers.

186   Almost all patients (n=2278/2489, 92%) had ≥1 underlying medical condition, with hypertension

187   (n=1428/2488, 57%), obesity (n=1154/2332, 50%), and chronic metabolic disease (n=1024/2486,

188   41%) most frequently documented. Among patients with chronic metabolic disease, 80% (n=819/1024)

189   had diabetes mellitus; hypertension alone was documented in only 4% (n=91/2490) of patients.

190   Seventeen percent (n=316/1892) took ACE-inhibitors, and 14% (n=257/1895) took ARBs prior to

191   hospitalization. The proportion of patients with any documented underlying medical condition

192   increased with age (p<0.05)(Figure 2A). Prevalence of CLD, neurologic conditions, obesity, and renal

193   disease varied between males and females (p<0.05, Figure 2B). CVD, CLD, and neurologic conditions

194   were more prevalent among non-Hispanic whites, while diabetes, hypertension, obesity and renal

195   disease were more common among non-Hispanic blacks (p<0.05, Figure 2C).

196   Cough (75%), fever or chills (74%), and shortness of breath (70%) were commonly

197   documented symptoms at admission (Table 2 and Appendix Table 4). Gastrointestinal symptoms,

198   including nausea, vomiting, and diarrhea, were documented in almost 30% of patients. Median length

199   of hospitalization was 6 days (IQR, 3–11), and median days from symptom onset to hospital admission

200   was 6 days (IQR, 3–8). Median values of initial vital signs were within normal range, except for elevated

201   blood pressure (Table 2). Thirty-three individuals had a pathogen detected from positive blood cultures

202   (Appendix Table 5). Viral co-detections from respiratory specimens were rare among those who were

203   tested (n=38/1549, 2.5%) (Appendix Table 6). Among 1932 patients with chest radiograph

204   performed, 92% (n=1769) were documented as abnormal with infiltrate or consolidation (n=1574/1932,

205   81%) documented most frequently (Appendix Table 7). Ninety-five percent (n=540/566) of patients with

206   chest computerized tomography (CT) had abnormal findings, and ground glass opacity

207   was documented in 62% (n=350/566) (Appendix Table 7).

208   Forty-five percent (n=1125/2482) of patients received investigational medication regimens for

209   COVID-19 during hospitalization (Table 2). The most common regimens included hydroxychloroquine

210   (n=1065/2479, 43%) and the combination of azithromycin and ≥1 COVID-19 treatment (n=725/2479,

211   29%) (non-mutually exclusive categories). The most frequent discharge diagnoses recorded in hospital

212   discharge summaries were pneumonia (n=1395/2485, 56%), acute respiratory failure (n=999/2487,

213   40%), acute renal failure (n=456/2,485, 18%), and sepsis (n=443/2,479, 18%).

214   Thirty-two percent (n=798/2490) of patients required ICU admission, with a median length of

215   ICU stay of 6 days (range, 1-41; IQR, 2–11) (Table 2). Median days from symptom onset to ICU

216   admission was 7 days (range, 0–25; IQR, 4–10), and median days from hospital admission to ICU

217   admission was 1 day (range, 0–19; IQR, 0–2). Among 2,489 hospitalized patients, the highest respiratory

218   support received was invasive mechanical ventilation in 19% (n=462), bilevel positive airway pressure

219   (BIPAP) or continuous positive airway pressure (CPAP) in 3% (n=82), and high flow nasal cannula (HFNC)

220   in 7% (n=170). Fifty-three percent (n=246/462) of patients that received invasive mechanical ventilation

221   died in-hospital (median age, 71 years; IQR, 62–79); the proportion of patients receiving mechanical

222   ventilation who died increased with age (p<0.0001). Vasopressors were used in 15% (n=373/2486) of

223   patients, while renal replacement therapy was used in 5% (n=115/2487). As age increased, so did

224   the proportion of patients who required ICU admission, invasive mechanical ventilation, and

225   vasopressors (p<0.05, Figure 3A). Males were admitted to the ICU and treated with invasive mechanical

226   ventilation, HFNC, or vasopressors more frequently than females (p<0.05) (Figure 3B). Non-Hispanic

227   whites more frequently received BIPAP, CPAP or HFNC (p<0.05, Figure 3C).

228   Overall, seventeen percent (n=420/2490) of patients died during hospitalization (Table 2). The

229   proportion of patients who died increased with increasing age groups, ranging from 3% among 18–49

230   years to 10% among 50–64 years to 29% among ≥65 years (Figure 3A). Males died more frequently

231   compared to females (p<0.05) (Figure 3B), as did non-Hispanic whites compared to other

232   race/ethnicities (p<0.05, Figure 3C).

233   Among 420 patients who died, median age was 76 years (range, 24–97; IQR, 66–85); 58%

234   (n=244) were male; 71% (n=299) were admitted to the ICU; and 59% (n=246) received invasive

235   mechanical ventilation. The median length of hospitalization among patients who died was 7 days

236   (range, 0–40; IQR, 4–12).

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238   **Risk factors for ICU admission and death**

239   Factors independently associated with ICU admission included age 50–64 years (adjusted risk

240   ratio (aRR) = 1.53; 95% confidence interval (CI), 1.28 to 1.83); 65–74 years (aRR = 1.65; CI, 1.34 to 2.03);

241   75–84 years (aRR = 1.84; CI, 1.60 to 2.11); ≥85 years (aRR = 1.43; CI, 1.00 to 2.04); male sex (aRR = 1.34;

242   CI, 1.20 to 1.50); obesity (aRR = 1.31; CI, 1.16 to 1.47); diabetes (aRR = 1.13; CI, 1.03 to 1.24); and

243   immunosuppression (aRR = 1.29; CI, 1.13 to 1.47) (Table 3A).

244   Independent factors associated with in-hospital mortality included age 50–64 years (aRR = 3.11;

245   CI 1.50 to 6.46); age 65–74 years (aRR = 5.77; CI, 2.64 to 12.64); age 75–84 years (aRR = 7.67; CI, 3.35 to

246   17.59); age ≥85 years (aRR = 10.98; CI, 5.09 to 23.69); male sex (aRR = 1.30; CI, 1.14 to 1.49); diabetes

247   (aRR = 1.19; CI, 1.01 to 1.40); CLD (aRR = 1.31; CI, 1.13 to 1.52); CVD (aRR = 1.28; CI, 1.03 to 1.58);

248   neurologic disorders (aRR = 1.25; CI, 1.04 to 1.50); renal disease (aRR = 1.33; CI, 1.10 to 1.61); and

249   immunosuppression (aRR = 1.39; CI, 1.13 to 1.70) (Table 3B).

250   Having ≥3 underlying medical conditions was significantly associated with higher risk of

251   ICU admission and death after adjusting for age group, sex, and race/ethnicity (Appendix Table 8).

252

253   **DISCUSSION**

254   Using a geographically diverse, multi-site, population-based U.S. surveillance system, we found

255   that among adults hospitalized with laboratory-confirmed COVID-19, almost one-third required ICU

256   admission, 19% received invasive mechanical ventilation, and 17% died during hospitalization. About

257   75% of patients were ≥50 years, and >90% had underlying medical conditions. Older age, being male,

258   and the presence of certain underlying medical conditions were associated with a higher risk of ICU

259   admission and in-hospital mortality. Race/ethnicity was not independently associated with either

260   outcome among hospitalized patients. This information can alert healthcare providers to patients at

261   greatest risk of severe outcomes and help target prevention strategies and future interventions.

262   In a published COVID-NET analysis, we found that when comparing the racial/ethnic distribution

263   of residents of the surveillance catchment areas to the racial/ethnic distribution of COVID-19-associated

264   hospitalizations, non-Hispanic blacks were disproportionately hospitalized with COVID-19 compared to

265   non-Hispanic whites (10). In this analysis, however, we found that once hospitalized, non-Hispanic

266   blacks did not have increased risk of poorer outcomes compared to other race/ethnicities after adjusting

267   for age and underlying conditions. In a preprinted article of U.S. Veterans seeking care at VA Hospitals,

268   Rentsch et al. found no association between black race and ICU admission (13). Similarly, a large study

269   of patients hospitalized in New York City did not find race/ethnicity to be associated with ICU admission

270   or death (4).

271   COVID-19-associated hospitalizations, ICU admissions, and deaths have been shown to occur

272   more frequently with increasing age (6, 9, 14). In our study, age ≥65 years was the strongest

273   independent predictor of ICU admission and in-hospital mortality. Persons aged 75–84 years had the

274   highest the risk of ICU admission compared to 18-49 years old, and those ≥85 years experienced 11

275   times the risk of death. These findings are similar to other studies from China, Europe, and the United

276   States (4, 9, 14-17). Our data provide support that older persons are particularly vulnerable to severe

277   COVID-19 disease and should be targeted for aggressive preventive measures (8).

278   Being male was associated with a higher risk of ICU admission and death after adjusting for age,

279   race/ethnicity and underlying conditions. Other studies have similarly shown male sex to be associated

280   with COVID-19-associated hospitalizations (4, 18), ICU admissions (19), and need for mechanical

281   ventilation (20).

282   Similar to other U.S. studies, we found that nearly all hospitalized patients with COVID-19 had at

283   least one underlying medical condition (4). In contrast, underlying medical conditions were documented

284   in only 25–50% of hospitalized cases from China (3, 21). Our analysis further demonstrated that a higher

285   number of underlying medical conditions increased the risk of ICU admission (1.3 times the risk in

286   persons with ≥3 vs. no underlying condition) and in-hospital mortality (1.8 times the risk in persons with

287   ≥3 vs. no underlying condition).

288   In a retrospective case study among 1590 laboratory-confirmed hospitalized COVID-19 cases in

289   575 Chinese hospitals, Guan et al. found that after adjusting for age and smoking status, chronic

290   obstructive pulmonary disease, diabetes, hypertension and malignancy were risk factors for a composite

291   endpoint of ICU admission, invasive mechanical ventilation, and death (3). Similarly, we found an

292   association between underlying medical conditions and severe outcomes, with diabetes, CLD, CVD,

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293   neurologic disease, renal disease and immunosuppression associated with in-hospital death, and

294   diabetes, obesity, and immunosuppression associated with ICU admission. While hypertension was

295   highly prevalent in our patient population, it was not associated with ICU admission or death. Additional

296   studies are needed to determine whether hypertension, which is also highly prevalent in the U.S.

297   population, increases the risk of COVID-19-associated hospitalizations and whether the duration of

298   hypertension and the degree to which it is controlled impact the risk for severe COVID-19 disease.

299   Similarly, the associations between the duration and degree of glycemic control in diabetes and severity

300   of COVID-19 disease require further investigation. Obesity, which was also highly prevalent in this

301   cohort, imparted increased risk for ICU admission, but not death. This finding may, in part, be explained

302   by a trend of decreasing obesity prevalence with increasing age, which was a strong risk factor for

303   mortality. Healthcare providers should be aware of these findings to appropriately triage and manage

304   patients with high-risk conditions that may either increase risk for hospitalization or poorer outcomes

305   once hospitalized (22, 23).

306   We collected data on initial symptoms, vital signs and laboratory values to characterize disease

307   severity at admission. While approximately 70% of patients had shortness of breath at admission, the

308   median oxygen saturation at admission was 94% on room air. Other admission vital signs and laboratory

309   values were also largely within normal ranges. Because we did not collect data on vital signs or

310   laboratory values during the hospital course, we may not have fully captured the onset of clinical

311   deterioration that has been reported during the second week after illness onset (24). We limited our

312   analysis to patients that had either been discharged or died in-hospital and found that 15% of patients

313   received vasopressor support, and 19% received invasive mechanical ventilation. Other U.S. studies

314   have found that up to 32% of hospitalized patients have received vasopressors and 29–33% have

315   received invasive mechanical ventilation (19, 20), though some of these studies included patients who

316   were still hospitalized at the time of analysis. In our study, 53% of patients requiring mechanical

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317   ventilation died, which is higher than the 36% reported in a recent study from New York City (4). In

318   general, the proportion of patients with severe outcomes was higher in the United States than reported

319   from China (6). Differences between patients' outcomes in the United States and China may reflect

320   differences in clinical practices or varying thresholds for hospitalization (18). These proportions of

321   severe outcomes among U.S. patients are also generally higher than those found in U.S. adults

322   hospitalized with seasonal influenza (25, 26). Our findings may help to inform resource planning and

323   allocation in healthcare facilities during the COVID-19 pandemic.

324   There are several limitations to our analysis. First, it is likely that not all COVID-19-associated

325   hospitalizations were captured because of the lack of widespread testing capability during the study

326   period and because identification of COVID-19 patients was largely reliant on clinician-directed testing.

327   Second, clinical practices and availability of specific interventions may differ across hospitals, which

328   might have influenced findings. Third, COVID-NET is an ongoing surveillance system, and only 15% of

329   the 16,318 COVID-19 hospitalized patients were included, representing those who were discharged or

330   died in-hospital during March 1–May 2, 2020 and for whom medical records were available and chart

331   abstractions were completed. These restrictions may have resulted in selection bias. However, there

332   was no difference in the age and sex distribution between cases included and excluded from the

333   analysis. The geographic distribution of cases included versus excluded from this analysis differed,

334   which may have impacted the racial and ethnic distribution of cases included in this analysis as

335   compared to the racial and ethnic distribution of the surveillance catchment population; however, as we

336   do not yet have complete data on race/ethnicity for all identified cases, we were not able to assess this

337   further. Nevertheless, COVID-NET encompasses a large geographic area with multiple hospitals and

338   likely offers a more racially and ethnically diverse patient population compared to other single-center or

339   state-based studies. Lastly, small counts limited our ability to determine risk factors for severe

340   outcomes among all racial and ethnic groups. COVID-NET data will become more robust as additional

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341   medical chart reviews are completed and may allow further investigation within these racial and ethnic

342   groups over time.

343   Based on preliminary findings from this multi-site, geographically diverse study, a high

344   proportion of patients hospitalized with COVID-19 received aggressive interventions and had poor

345   outcomes. Increasing age was the strongest predictor of in-hospital mortality. Prevention strategies,

346   such as social distancing and rigorous hand hygiene, are key to minimizing the risk of infection in high-

347   risk patients. These data help to characterize persons at highest risk for severe COVID-19-associated

348   disease in the United States and to define target groups for future prevention and treatment strategies

349   as they become available.

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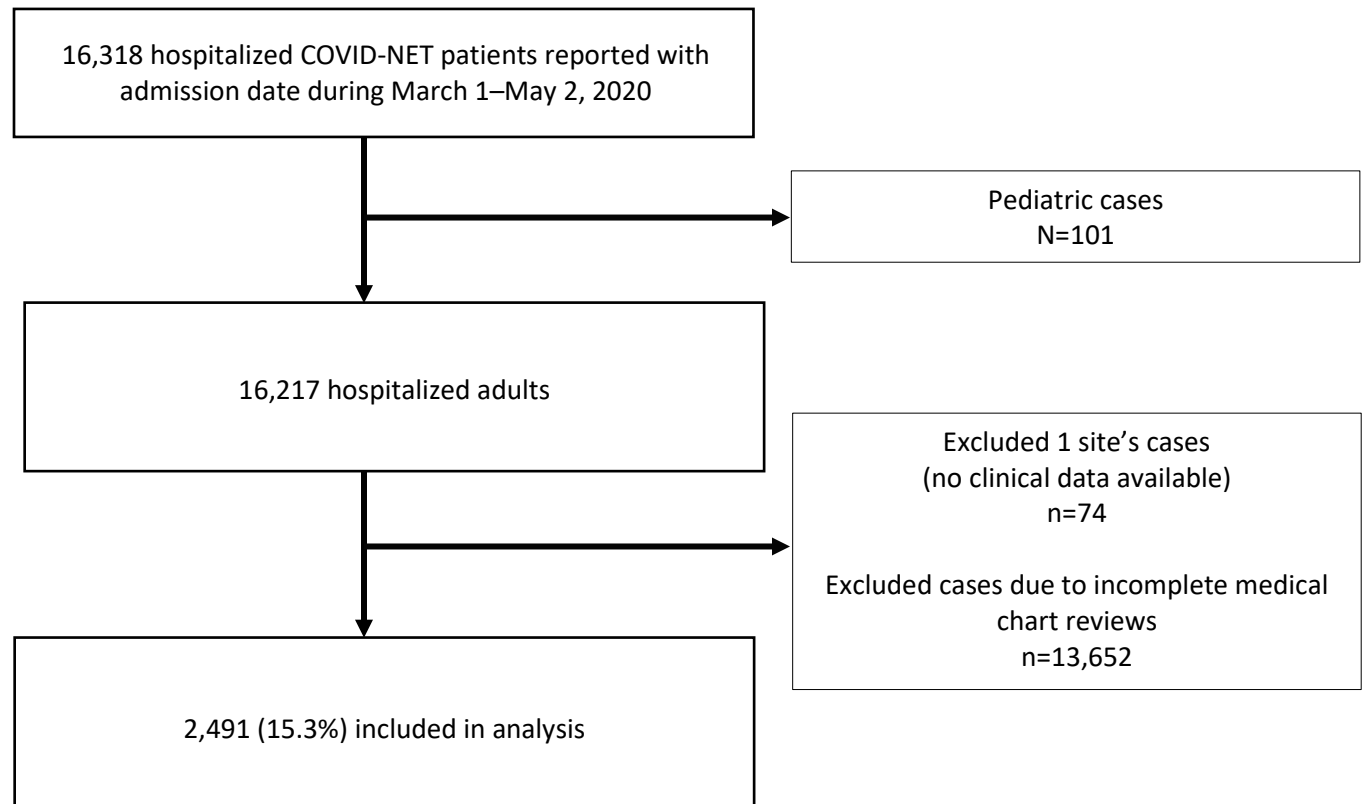443

Figure 1. Flow diagram of analytic sample.

Table 1. Demographic and clinical characteristics of adults hospitalized with COVID-19 — COVID-NET, 13 sites (N=2,491)

	n, %
Age in years (median, IQR)	62, 50–75
Age category	
18–39	302 (12.1)
40–49	319 (12.8)
50–64	744 (29.9)
65–74	478 (19.2)
75–84	397 (15.9)
85+	251 (10.1)
Male	1,326 (53.2)
Race/ethnicity (n=2,490)	
Non-Hispanic White	1,178 (47.3)
Non-Hispanic Black	755 (30.3)
Hispanic	306 (12.3)
Non-Hispanic Other[*]	158 (6.3)
Unknown	93 (3.7)
Residence at time of hospitalization (n=2,482)	
Private residence	1,899 (76.5)
Facility[†]	495 (19.9)
Homeless/Shelter	40 (1.6)
Other[‡]	45 (1.8)
Unknown	3 (0.1)
Smoker (n=2,489)	
Current	150 (6.0)
Former	642(25.8)
No or Unknown	1,697 (68.2)
Any underlying condition[§] (n=2,489)	2,278 (91.5)
Hypertension (n=2,488)	1,428 (57.4)
Obesity[‖] (n=2,332)	1154 (49.7)
Severe obesity[‖] (n=2,332)	325 (14.0)
Chronic metabolic disease (n=2,486)	1,024 (41.2)
Diabetes mellitus (n=2,486)	819 (32.9)
Chronic lung disease (n=2,484)	747 (30.1)
Asthma (n=2,484)	314 (12.6)
Chronic Obstructive Pulmonary Disease (n=2,484)	266 (10.7)
Cardiovascular disease (n=2,486)	859 (34.6)
Coronary artery disease (n=2,486) [¶]	352 (14.2)
Congestive heart failure (n=2,486)	284 (11.4)
Neurologic disease (n=2,484)	548 (22.1)
Renal disease (n=2,488)	386 (15.5)
Immunosuppressive condition (n=2,487)	263 (10.6)
Gastrointestinal or Liver disease (n=2,486)	118 (4.7)
Hematologic condition (n=2,483)	80 (3.2)
Rheumatologic or autoimmune disease (n=2,486)	77 (3.1)

Pregnancy (n=279)[**]	36 (12.9)
Number of underlying medical conditions (by major category) (n=2,490)	
0	212 (8.5)
1	480 (19.3)
2	510 (20.5)
3+	1,288 (51.7)
Outpatient use of medications	
ACE-inhibitor (n=1,892)	316 (16.7)
Angiotensin receptor blockers (ARBs) (n=1,895)	257 (13.6)

IQR = interquartile range; ACE = angiotensin-converting enzyme inhibitors

[*]Non-Hispanic Other includes: Non-Hispanic American Indian or Alaskan Native (n=24), Non-Hispanic Asian (n=128), and Non-Hispanic multiracial (n=6)

[†]Facility includes rehabilitation facilities, assisted living/residential care, group homes, nursing homes, skilled nursing facilities, long-term care facilities, long-term acute care hospitals, alcohol/drug treatment centers, and psychiatric facilities.

[‡]Other includes home with services (n=43), correctional facility (n=1), and hospice (n=1).

[§]See Supplementary Table 1 for definitions of underlying medical conditions.

[‖]Obesity is defined as body mass index (BMI) ≥30 kg/m^2, and severe obesity is defined as BMI ≥40 kg/m^2.

[¶]Includes coronary artery disease, history of coronary artery bypass grafting, and history of myocardial infarction

[**]Denominator includes women aged 15–49 years.

Figure 2. Select underlying medical conditions[*] of adults hospitalized with COVID-19, by age, sex, and race/ethnicity — COVID-NET, 13 sites (N=2,491)

A. Age (n=2,489)
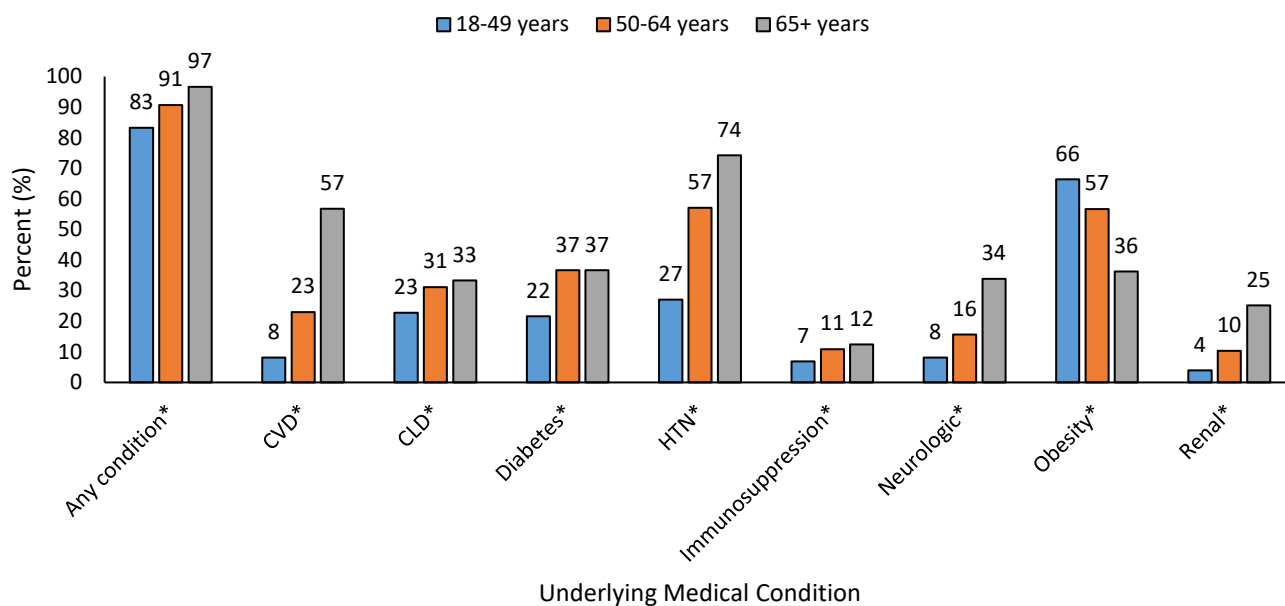
*p-value <0.05
CVD = Cardiovascular disease (excluding hypertension); HTN = hypertension; CLD = chronic lung disease.

B. Sex (n=2,489)
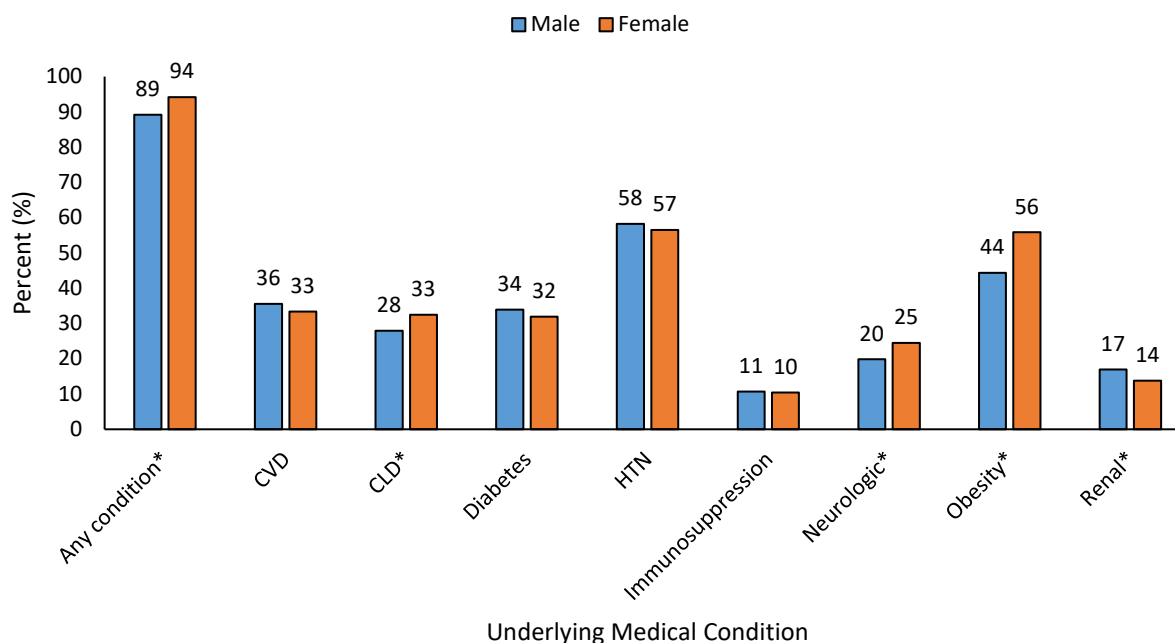
*p-value <0.05
CVD = Cardiovascular disease (excluding hypertension); HTN = hypertension; CLD = chronic lung disease.

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C. Race/Ethnicity (n=2,488)

*p-value <0.05
CVD = Cardiovascular disease (excluding hypertension); HTN = hypertension; CLD = chronic lung disease.

[*]The underlying medical condition categories are not mutually exclusive. Patients can have more than once underlying medical condition.

Table 2. Clinical course, interventions, and outcomes of adults hospitalized with COVID-19 — COVID-NET, 13 sites (N=2,491)
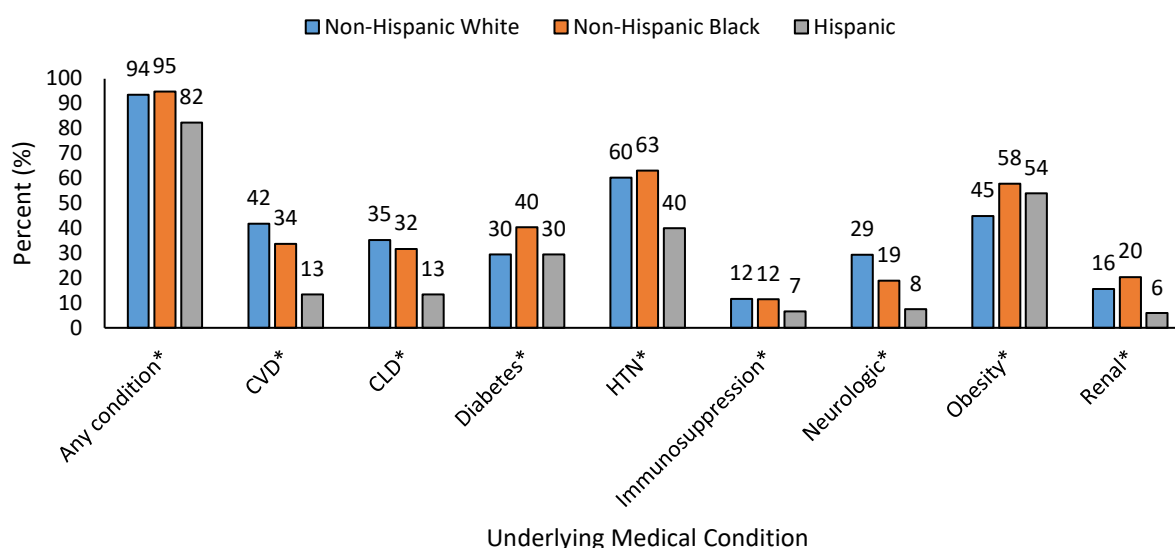
	%
Symptoms on admission* (n=2,482)	
Cough	1,855 (74.7)
Fever or chills	1,835 (73.9)
Shortness of breath	1,740 (70.1)
Muscle aches/myalgias	722 (29.1)
Diarrhea	676 (27.2)
Nausea or vomiting	621 (25.0)
Hospitalization length of stay in days, median (IQR) (n=2,487)	6 (3–11)
Days from symptom onset to hospitalization (median, IQR) (n=1,937)	6 (3–8)
Initial vital signs	
Temperature (°Celsius, median, IQR) (n=2,469)	37.4 (36.9–38.1)
Heart rate (median, IQR) (n=2,479)	95 (83–108)
Systolic blood pressure (median, IQR) (n=2,483)	132 (118–147)
Respiratory rate (median, IQR) (n=2,461)	20 (18–23)
Oxygen saturation (among those on room air) (median, IQR) (n=1,969)	94 (92–97)
Initial laboratory values	
White blood cell count (median, IQR) – per mm^3 (n=2,458)	6.3 (4.7–8.5)
Hematocrit (median, IQR) - % (n=2,461)	40.6 (36.9–43.9)
Platelet count (median, IQR) – per mm^3 (n=2,461)	195.0 (156.0–249.0)
Sodium (median, IQR) – mmol/L (n=2,460)	137.0 (134.0–139.0)
Blood Urea Nitrogen (median, IQR) – mg/dl (n=2,443)	16.0 (11.0–25.0)
Creatinine (median, IQR) – mg/dl (n=2,462)	1.0 (0.8–1.4)
Glucose (median, IQR) – mg/dl (n=2,459)	117.0 (102.0–149.0)
Aspartate transaminase (median, IQR) – U/L (n=2,149)	40.0 (28.0–61.0)
Alanine aminotransferase (median, IQR) – U/L (n=2,164)	31.0 (20.0–50.0)
Arterial pH (median, IQR) (n=487)	7.35 (7.40–7.45)
Abnormal chest X-ray during hospitalization (n=1,932)	1,769 (91.6)
Abnormal chest CT during hospitalization (n=566)	540 (95.4)
Ground glass opacities (n=566)	350 (61.8)
Investigational medication regimens for COVID-19† (n=2,482)	1,125 (45.3)
Hydroxychloroquine‡ (n=2,479)	1,065 (43.0)
Azithromycin + ≥ 1 other COVID-19 treatment (n=2,479)	725 (29.2)
Tocilizumab (n=2,479)	103 (4.2)
Atazanavir (n=2,479)§	94 (3.8)
Remdesivir (n=2,479)‡	53 (2.1)
Lopinavir/ritonavir (n=2,479)§	27 (1.1)
Convalescent plasma (n=2,479)	9 (0.4)
Chloroquine (n=2,479)	7 (0.3)
Sarilumab (n=2,479)‡	6 (0.2)
Investigational drug (not specified) RCT (n=2,479)	1 (0.0)

ICU Admission (n=2,490)	798 (32.0)
ICU length of stay (days, median, IQR) (n=771)	6 (2–11)
Highest level of respiratory support required (n=2,489)	
Invasive mechanical ventilation	462 (18.6)
BIPAP or CPAP	82 (3.3)
High flow nasal cannula	170 (6.8)
ECMO (n=2,487)	9 (0.4)
Vasopressor use (n=2,486)	373 (15.0)
Systemic steroids (n=2,489)	321 (12.9)
Renal replacement therapy (n=2,487)	115 (4.6)
Discharge Diagnoses[‖]	
Pneumonia (n=2,485)	1,395 (56.1)
Acute respiratory failure (n=2,487)	999 (40.2)
Acute renal failure (n=2,485)	456 (18.4)
Sepsis (n=2,479)	443 (17.9)
Acute respiratory distress syndrome (n=2,485)	255 (10.3)
Encephalitis (n=2,482)	151 (6.1)
Congestive heart failure (n=2,485)	51 (2.1)
Asthma exacerbation (n=2,486)	43 (1.7)
COPD exacerbation (n=2,486)	39 (1.6)
Acute myocardial infarction (n=2,485)	38 (1.5)
In-hospital death (n=2,490)	420 (16.9)

IQR = interquartile range; CT = computed tomography; ICU = intensive care unit; BIPAP = bilevel positive airway pressure; CPAP = continuous positive airway pressure; ECMO = extracorporeal membrane oxygenation; COPD = chronic obstructive pulmonary disease

[*]See Supplementary Table 2 for additional symptom data.

[†]Not mutually exclusive categories

[‡]Includes randomized controlled trials where it cannot be determined whether the case received treatment vs. placebo (remdesivir, 24; hydroxychloroquine 15; and sarilumab 5).

[§]Persons with HIV/AIDS were excluded.

[‖]Discharge diagnoses recorded from the hospital discharge summary and not based on ICD-10 discharge codes.

Figure 3. Interventions and outcomes of adults hospitalized with COVID-19, by age, sex, and race/ethnicity — COVID-NET, 13 sites (N=2,491)

A. Age (n=2,490)
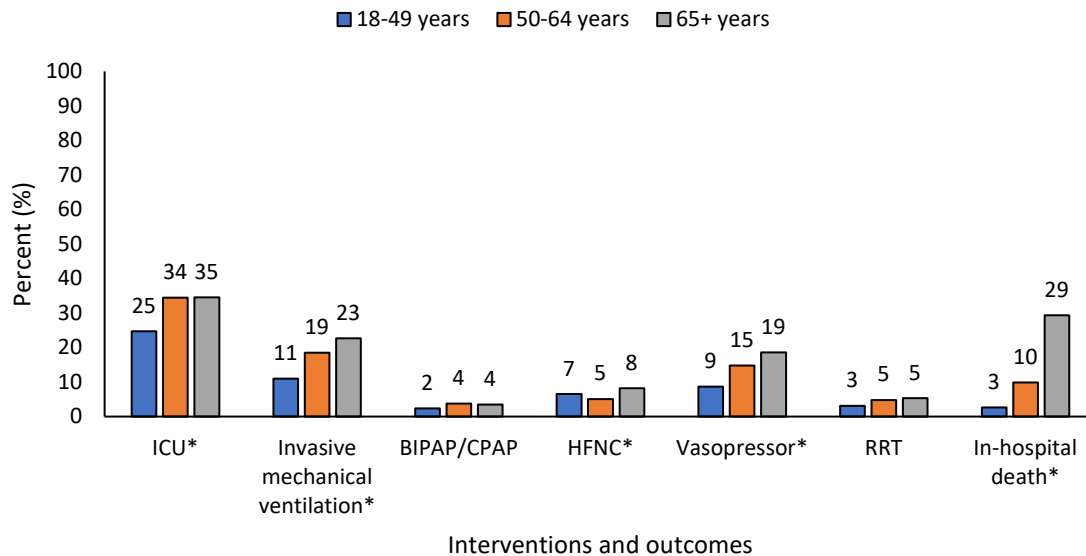
*p-value <0.05
ICU = intensive care unit; BIPAP = bilevel positive airway pressure; CPAP = continuous positive airway pressure; HFNC = high flow nasal cannula; RRT = renal replacement therapy

B. Sex (n=2,490)
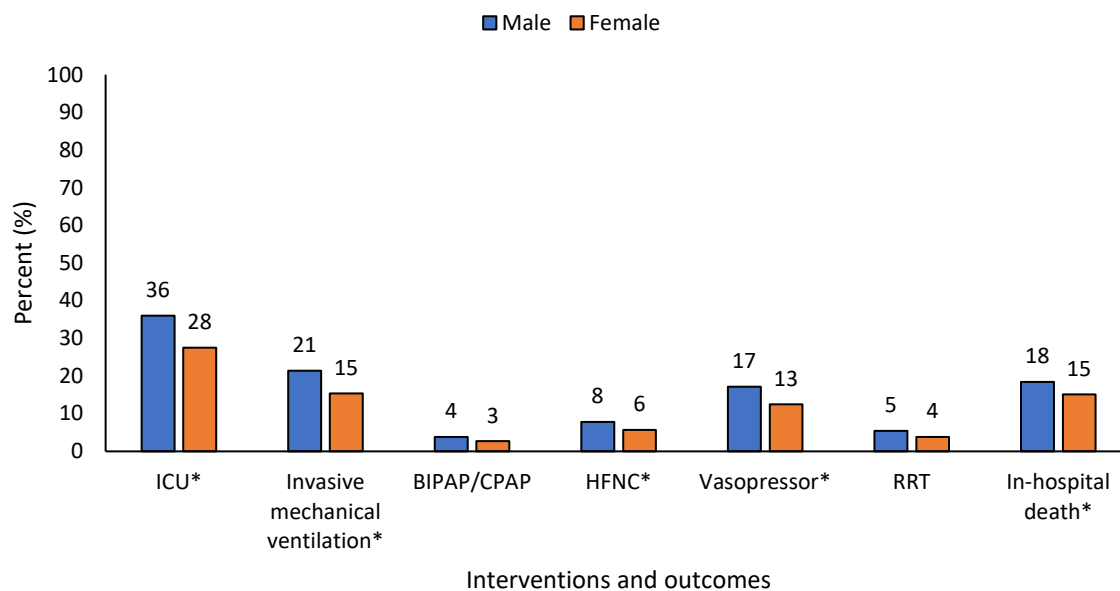
ICU = intensive care unit; BIPAP = bilevel positive airway pressure; CPAP = continuous positive airway pressure; HFNC = high flow nasal cannula; RRT = renal replacement therapy

C. Race/Ethnicity (n=2,490)
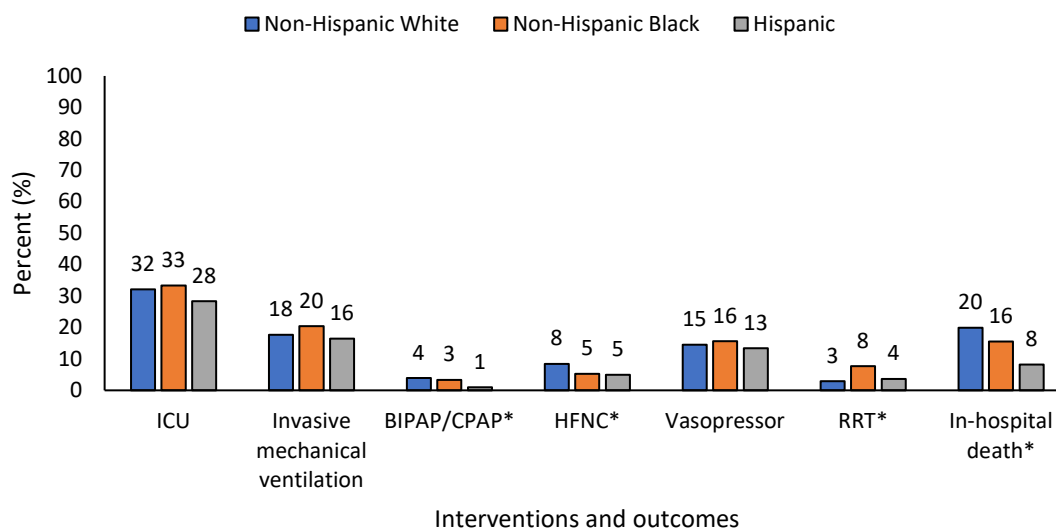
*p-value <0.05
ICU = intensive care unit; BIPAP = bilevel positive airway pressure; CPAP = continuous positive airway pressure; HFNC = high flow nasal cannula; RRT = renal replacement therapy

* For mechanical ventilation, BIPAP/CPAP, and HFNC, patients are assigned based on the highest level of respiratory support required during hospitalization (i.e. invasive mechanical ventilation followed by BIPAP or CPAP, followed by high flow nasal cannula).

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Table 3. Risk factors for ICU admission and in-hospital mortality — COVID-NET, 13 sites (N=2,491)

A.   ICU Admission (N=2,490)[*]

Characteristic	Category	Not in ICU (n=1,692)	In ICU (n=798)	Total (N=2,490)	P-value	Unadjusted Risk Ratio	95% CI	Adjusted Risk Ratio	95% CI
Age category					<0.0001				
	18–39 years	240 (14)	62 (8)	302		Reference	N/A	Reference	N/A
	40–49 years	227 (13)	91 (11)	318		1.38	(1.08, 1.75)	1.22	(0.96, 1.56)
	50–64 years	488 (29)	256 (32)	744		1.64	(1.36, 1.99)	1.53	(1.28, 1.83)
	65–74 years	298 (18)	180 (23)	478		1.80	(1.50, 2.16)	1.65	(1.34, 2.03)
	75–84 years	248 (15)	149 (19)	397		1.80	(1.52, 2.14)	1.84	(1.6, 2.11)
	85+ years	191 (11)	60 (8)	251		1.16	(0.87, 1.54)	1.43	(1.00, 2.04)[†]
Sex					<0.0001				
	Female	844 (50)	320 (40)	1164		Reference	N/A	Reference	N/A
	Male	848 (50)	478 (60)	1326		1.30	(1.20, 1.42)	1.34	(1.20, 1.50)
Race/ethnicity					0.63				
	NH White	800 (47)	378 (47)	1178		Reference		Reference	N/A
	NH Black	503 (30)	251 (31)	754		1.03	(0.93, 1.13)	1.01	(0.89, 1.15)
	Hispanic	219 (13)	87 (11)	306		0.86	(0.69, 1.09)	0.96	(0.76, 1.21)
	NH Other	105 (6)	53 (7)	158		1.03	(0.89, 1.18)	1.06	(0.83, 1.37)
	Unknown	64 (4)	29 (4)	93		0.97	(0.77, 1.22)	0.93	(0.74, 1.15)
Smoker					0.0001				
	No/Unknown	1185 (70)	512 (64)	1697		Reference		Reference	N/A
	Former	395 (23)	247 (31)	642		1.26	(1.10, 1.43)	1.07	(0.92, 1.24)
	Current	112 (7)	38 (5)	150		0.84	(0.67, 1.06)	0.81	(0.61, 1.06)
Hypertension					0.03				
	No	746 (44)	314 (39)	1060		Reference		Reference	N/A
	Yes	945 (56)	483 (61)	1428		1.13	(1.01, 1.27)	0.92	(0.79, 1.07)
Obesity (BMI≥30)					0.0013				
	No	821 (53)	347 (46)	1168		Reference	N/A	Reference	N/A
	Yes	739 (47)	415 (54)	1154		1.25	(1.14, 1.37)	1.31	(1.16, 1.47)

Diabetes					<0.0001				
	No	1176 (70)	491 (62)	1667		Reference	N/A	Reference	N/A
	Yes	513 (30)	306 (38)	819		1.20	(1.08, 1.34)	1.13	(1.03, 1.24)
Chronic Lung Disease					<0.0001				
	No	1222 (72)	515 (65)	1737		Reference	N/A	Reference	N/A
	Yes	466 (28)	281 (35)	747		1.25	(1.09, 1.44)	1.17	(1.00, 1.37)[‡]
Cardiovascular Disease					0.006				
	No	1136 (67)	491 (62)	1627		Reference	N/A	Reference	N/A
	Yes	553 (33)	306 (38)	859		1.17	(1.09, 1.26)	0.98	(0.88, 1.09)
Neurologic					0.06				
	No	1297 (77)	639 (80)	1936		Reference	N/A	Reference	N/A
	Yes	390 (23)	158 (20)	548		0.88	(0.76, 1.03)	0.85	(0.70, 1.04)
Renal					0.004				
	No	1453 (86)	649 (81)	2102		Reference	N/A	Reference	N/A
	Yes	238 (14)	148 (19)	386		1.23	(1.11, 1.37)	1.05	(0.94, 1.16)
Immuno-suppression					<0.0001				
	No	1541 (91)	683 (86)	2224		Reference	N/A	Reference	N/A
	Yes	149 (9)	114 (14)	263		1.39	(1.22, 1.58)	1.29	(1.13, 1.47)
Gastro-intestinal or Liver					0.87				
	No	1609 (95)	759 (95)	2368		Reference	N/A	N/A	N/A
	Yes	81 (5)	37 (5)	118		0.98	(0.80, 1.20)	N/A	N/A
Hematologic					0.87				
	No	1632 (97)	771 (97)	2403		Reference	N/A	N/A	N/A
	Yes	55 (3)	25 (3)	80		0.96	(0.76, 1.22)	N/A	N/A
Rheumatologic or Autoimmune					0.87				
	No	1637 (97)	772 (97)	2409		Reference	N/A	N/A	N/A
	Yes	53 (3)	24 (3)	77		0.96	(0.74, 1.26)	N/A	N/A
Outpatient ACE-Inhibitor Use					0.99				
	No/Unknown	1063 (83)	513 (83)	1576		Reference	N/A	N/A	N/A
	Yes	213 (17)	103 (17)	316		0.99	(0.84, 1.18)	N/A	N/A

Outpatient Angiotensin Receptor Blocker Use					0.04				
	No/Unknown	1118 (88)	520 (84)	1638		Reference	N/A	Reference	N/A
	Yes	159 (12)	98 (16)	257		1.18	(1.06, 1.31)	1.07	(0.95, 1.21)

ICU = intensive care unit; CI = confidence interval; N/A = not applicable; ACE = angiotensin-converting-enzyme

*Final model included age, sex, race/ethnicity, smoking status, hypertension, obesity, diabetes, chronic lung disease, cardiovascular disease, neurologic disease, renal disease, immunosuppression, and outpatient use of an angiotensin receptor blocker.

[†]p=0.0494

[‡]p=0.0524

B. In-hospital mortality (N=2,490)[*]

Characteristic	Category	Discharged Alive (n=2070)	In-Hospital Death (n=420)	Total (N=2490)	P-value	Unadjusted Risk Ratio	95% CI	Adjusted Risk Ratio	95% CI
Age					<0.0001				
	18-39 years	296 (14)	6 (1)	302		Reference	N/A	Reference	N/A
	40–49 years	308 (15)	10 (2)	318		1.51	(0.59, 3.85)	1.23	(0.51, 2.99)
	50-64 years	670 (32)	74 (18)	744		4.62	(2.1, 10.18)	3.11	(1.50, 6.46)
	65–74 years	375 (18)	103 (25)	478		9.88	(4.28, 22.85)	5.77	(2.64, 12.64)
	75–84 years	277 (13)	120 (29)	397		13.89	(6.12, 31.52)	7.67	(3.35, 17.59)
	85+ years	144 (7)	107 (25)	251		19.46	(9.39, 40.35)	10.98	(5.09, 23.69)
Sex					0.03				
	Female	988 (48)	176 (42)	1164		Reference	N/A	Reference	N/A
	Male	1082 (52)	244 (58)	1326		1.22	(1.02, 1.47)	1.30	(1.14, 1.49)
Race/ethnicity					<0.0001				
	NH White	944 (46)	234 (56)	1178		Reference	N/A	Reference	N/A
	NH Black	637 (31)	117 (28)	754		0.75	(0.57, 0.99)	1.07	(0.85, 1.35)
	Hispanic	281 (14)	25 (6)	306		0.42	(0.32, 0.56)	1.17	(0.91, 1.51)
	NH Other	132 (6)	26 (6)	158		0.82	(0.54, 1.25)	1.26	(0.86, 1.82)
	Unknown	76 (4)	17 (4)	93		0.91	(0.44, 1.88)	1.30	(0.74, 2.31)
Smoker					<0.0001				
	No/Unknown	1461 (71)	236 (56)	1697		Reference	N/A	Reference	NA
	Former	481 (23)	161 (38)	642		1.75	(1.51, 2.04)	1.14	(0.98, 1.33)
	Current	128 (6)	22 (5)	150		1.06	(0.75, 1.49)	1.22	(0.99, 1.51)
Hypertension					<0.0001				
	No	955 (46)	105 (25)	1060		Reference	N/A	Reference	NA
	Yes	1114 (54)	314 (75)	1428		2.18	(1.66, 2.86)	1.07	(0.79, 1.45)
Obesity (BMI≥30)					0.001				
	No	944 (49)	224 (58)	1168		Reference	N/A	Reference	N/A
	Yes	992 (51)	162 (42)	1154		0.73	(0.61, 0.86)	1.09	(0.92, 1.30)
Diabetes					<0.0001				

	No	1423 (69)	244 (58)	1667		Reference	N/A	Reference	N/A
	Yes	644 (31)	175 (42)	819		1.44	(1.2, 1.72)	1.19	(1.01, 1.40
Chronic Lung Disease					<0.0001				
	No	1489 (72)	248 (59)	1737		Reference	N/A	Reference	N/A
	Yes	577 (28)	170 (41)	747		1.56	(1.27, 1.91)	1.31	(1.13, 1.52)
Cardiovascular Disease					<0.0001				
	No	1462 (71)	165 (39)	1627		Reference	N/A	Reference	N/A
	Yes	605 (29)	254 (61)	859		2.85	(2.42, 3.36)	1.28	(1.03, 1.58)
Neurologic					<0.0001				
	No	1674 (81)	262 (63)	1936		Reference	N/A	Reference	N/A
	Yes	391 (19)	157 (37)	548		2.10	(1.72, 2.56)	1.25	(1.04, 1.50)
Renal					<0.0001				
	No	1814 (88)	288 (69)	2102		Reference	N/A	Reference	N/A
	Yes	255 (12)	131 (31)	386		2.45	(2.04, 2.93)	1.33	(1.10, 1.61)
Immuno-suppression					<0.0001				
	No	1873 (91)	351 (84)	2224		Reference	N/A	Reference	N/A
	Yes	195 (9)	68 (16)	263		1.58	(1.33, 1.88)	1.39	(1.13, 1.70)
Gastro-intestinal or Liver					0.12				
	No	1975 (96)	393 (94)	2368		Reference	N/A	N/A	N/A
	Yes	92 (4)	26 (6)	118		1.30	(1.00, 1.70)	N/A	N/A
Hematologic					0.02				
	No	2005 (97)	398 (95)	2403		Reference	N/A	Reference	N/A
	Yes	59 (3)	21 (5)	80		1.54	(1.11, 2.12)	1.33	(0.93, 1.9)
Rheumatologic or Autoimmune					0.03				
	No	2010 (97)	399 (95)	2409		Reference	N/A	Reference	N/A
	Yes	57 (3)	20 (5)	77		1.53	(1.03, 2.29)	0.87	(0.66, 1.16)
Outpatient ACE-Inhibitor Use					0.99				
	No/Unknown	1312 (83)	264 (83)	1576		Reference	N/A	N/A	N/A
	Yes	263 (17)	53 (17)	316		0.98	(0.74, 1.30)	N/A	N/A
Outpatient Angiotensin					0.11				
	No/Unknown	1372 (87)	266 (84)	1638		Reference	N/A	N/A	N/A

Receptor Blocker Use	Yes	205 (13)	52 (16)	257		1.19	(0.91, 1.57)	N/A	N/A

CI = confidence interval; N/A = not applicable; ACE = angiotensin-converting-enzyme

*Final model adjusted for age, sex, race/ethnicity, smoker, hypertension, obesity, diabetes, chronic lung disease, cardiovascular disease, neurologic disease, renal disease, immunosuppression, hematologic disorders, and rheumatologic or autoimmune disease.