Clinical Features and Risk Factors for In-Hospital Mortality From COVID-19 Infection at a Tertiary Care Medical Center, at the Onset of the US COVID-19 Pandemic

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Abstract

Background: Mortality from COVID-19 has been associated with older age, black race, and comorbidities including obesity. Understanding the clinical risk factors and laboratory biomarkers associated with severe and fatal COVID-19 will allow early interventions to help mitigate adverse outcomes. Our study identified risk factors for in-hospital mortality among patients with COVID-19 infection at a tertiary care center, in Detroit, Michigan. Methods: We conducted a single-center, retrospective cohort study at a 776-bed tertiary care urban academic medical center. Adult inpatients with confirmed COVID-19 (nasopharyngeal swab testing positive by real-time reverse-transcriptase-polymerase-chain-reaction (RT-PCR) assay) from March 8, 2020, to June 14, 2020, were included. Clinical information including the presence of comorbid conditions (according to the Charlson Weighted Index of Comorbidity (CWIC)), initial vital signs, admission laboratory markers and management data were collected. The primary outcome was in-hospital mortality. Results: Among 565 hospitalized patients, 172 patients died for a case fatality rate of 30.4%. The mean (SD) age of the cohort was 64.4 (16.2) years, and 294 (52.0%) were male. The patients who died were significantly older (mean [SD] age, 70.4 [14.1] vs 61.7 [16.1] years; \( P < 0.0001 \)), more likely to have congestive heart failure (35 [20.3%] vs 47 [12.0%]; \( P = 0.009 \)), dementia (47 [27.3%] vs 48 [12.2%]; \( P < 0.0001 \)), hemiplegia (18 [10.5%] vs 18 [4.8%]; \( P = 0.01 \)) and a diagnosis of malignancy (16 [9.3%] vs 18 [4.6%]; \( P = 0.03 \)). From multivariable analysis, factors associated with an increased odds of death were age greater than 60 years (OR = 2.2, \( P = 0.003 \)), CWIC score (OR = 1.1, \( P = 0.023 \)), qSOFA (OR = 1.7, \( P < 0.0001 \)), WBC counts (OR = 1.1, \( P = 0.002 \)), lymphocytopenia (OR = 2.0, \( P = 0.003 \)), thrombocytopenia (OR = 1.9, \( P = 0.019 \)), albumin (OR = 0.6, \( P = 0.014 \)), and AST levels (OR = 2.0, \( P = 0.004 \)) on admission. Conclusions: This study identified risk factor for in-hospital mortality among patients admitted with COVID-19 in a tertiary care hospital at the onset of U.S. Covid-19 pandemic. After adjusting for age, CWIC score, and laboratory data, qSOFA remained an independent predictor of mortality. Knowing these risk factors may help identify patients who would benefit from close observations and early interventions.

Keywords
hospital mortality, infections, clinical research

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Severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2), is a novel coronavirus that causes coronavirus disease 2019 (COVID-19).\textsuperscript{1,2} It was identified in December 2019 in Wuhan, China and has become pandemic.\textsuperscript{3} Worldwide, 78,145,043 confirmed COVID-19 cases with 1,719,973 deaths were reported as of December 23, 2020.\textsuperscript{4} In the United States, a total of 18,238,314 cases have been reported with 322,851 deaths. Michigan had the highest observed case-fatality rate (CFR) in the United States in the early phase of U.S. pandemic.\textsuperscript{4,5}

Older age, black race and comorbidities including obesity are suggested risk factors for death from COVID-19. Studies from multiple countries revealed association between age \textgreater;65 years and comorbidities and increased risk of death.\textsuperscript{6-8} Preliminary U.S. data showed that 80% of deaths associated with COVID-19 were among older adults.\textsuperscript{9} Persons with diabetes and cardiovascular disease also had higher COVID-19-associated mortality.\textsuperscript{10} A study also reported a high death rate among nursing facilities, as expected from older and chronically ill populations.\textsuperscript{11} The Centers for Disease Control and Prevention's (CDC) aligns underlying causes of health disparities that include social determinants of health, racism and discrimination, economic and educational disadvantages, health care access and quality, and occupation. Miller et al reported significantly higher rates of COVID-19 diagnosis and death in disproportionately black counties which also had a greater incidence of diabetes, heart disease deaths and cerebrovascular deaths.\textsuperscript{12} Black/African-Americans comprise only 14% of Michigan's population, they accounted for 40% of deaths due to COVID-19.\textsuperscript{13} Obesity is often associated with chronic conditions, such as diabetes, hypertension, cardiac conditions, and cerebrovascular disease.

In a study from an integrated health system patient with a BMI of 18.5 to 24 kg/m\textsuperscript{2} in comparison to those with BMIs of 40 to 44 kg/m\textsuperscript{2} and greater than 45 kg/m\textsuperscript{2} the relative risk of dying was 2.68 (95\% CI, 1.43-5.04) and 4.18 (CI, 2.12-8.26), respectively. Increased risk for pro-inflammatory and pro-thrombotic states as well as poor ventilatory lung mechanics with obesity are poor prognostic factors.\textsuperscript{14} Our study identified risk factors at the time of admission for in-hospital mortality among COVID-19 patients in the early phase of this pandemic in a tertiary care hospital located in Detroit, Michigan.

**Study Setting and Design**

We conducted a single-center, retrospective cohort study at a 776-bed tertiary care urban academic medical center. The study was approved by the Ascension St John Hospital Institutional Review Board. Adult patients with confirmed COVID-19 (positive real-time reverse-transcriptase-polymerase-chain-reaction (RT-PCR) assay of a nasopharyngeal swab) from March 8, 2020, to June 14, 2020, were included.

**Data Collection**

Data were collected from the electronic medical record for all patients meeting inclusion criteria. Demographics included age, gender, race, and residential 9-digit zip code. Clinical information included the presence of comorbid conditions (according to the Charlson Weighted Index of Comorbidity), home medications, presenting symptoms, initial vital signs, admission laboratory and radiological findings, and outcome variables including the discharge disposition.

**Definitions**

Age was categorized both as quartiles and as \(\geq 60\) vs \(< 60\) years. Obesity and morbid obesity were defined according to CDC definitions.\textsuperscript{15} Pre-existing renal disease was defined as chronic dialysis, history of renal transplant, uremic syndrome, or a creatinine \(> 3\) mg/dL on prior admissions. Malignancy was included if active or treated in the last 5 years. Fever was defined as an oral temperature of 37.8 °C or higher. Leukopenia and lymphocytopenia were defined as white blood cell counts of less than 4 \(\times\) 10\(^9\)/L and absolute lymphocyte count less than 1.0 \(\times\) 10\(^9\)/L, respectively. Thrombocytopenia was defined as a platelet count less than 150 \(\times\) 10\(^9\)/L. Elevated ferritin and d dimer were defined as 4 and 6 times the upper limit of normal, respectively. Acute renal injury was defined as an increase in serum creatinine by \(\geq 0.3\) mg/dL (\(\geq 26.5\) μmol/L) within 48 hours or an increase in serum creatinine to \(\geq 1.5\) times baseline, known or presumed to have occurred within the prior 7 days.\textsuperscript{16} COVID-19 pneumonia was defined as an acute respiratory disorder meeting at least 3 out of 4 criteria: respiratory signs/symptoms (cough/dyspnea/tachypnea), fever, oxygen saturation below 94\%, and abnormal chest x-ray at the time of hospital admission. Uncomplicated illness, severe pneumonia, acute respiratory distress syndrome (ARDS) and septic shock were defined according to the WHO definitions.\textsuperscript{17} The 5-digit ZIP code was also used to collect median income from 2017 United States census data.\textsuperscript{18}

**Statistical Analysis**

Statistical analysis was performed using SPSS v. 27.0 (Armonk, NY). Descriptive statistics were generated to characterize the study group. Continuous variables were described as the mean with standard deviation or median with interquartile range; categorical variables were described as frequency distributions. Univariable analysis was done using Student’s t-test, the Mann-Whitney U test and chi-squared analysis. Variables that were found to be significant or near-significant (\(P < 0.09\)) predictors of mortality were then entered a multi-variable logistic regression model using a forward likelihood ratio algorithm. When 2 variables were measuring the same underlying factor, the variable with the highest univariable measure of association was used in the model. Results from the regression are reported as odds ratios with 95\% confidence intervals. All reported \(P\) values are 2-sided.

**Results**

A total of 565 hospitalized patients with confirmed SARS-CoV-2 infection were included. The mean (Standard Deviation—[SD]) age of the cohort was 64.4 (16.2) years, 294 (52.0\%) were male.
and 436 (77.2%) were black/African-American. The mean body mass index (BMI) of the cohort was 32.0 (9.02) kg/m². At least one comorbidity was present in 538 (95.2%) of patients. The most common co-morbidities were hypertension (418, 74.0%), obesity (300, 53.1%), and diabetes (219, 38.8%). The mean duration of symptoms prior to hospitalization was 5.29 (4.1) days. Fever was noted in 212 (37.5%) patients. An abnormal admission chest x-ray was found in 423 (74.9%) patients, and pneumonia was diagnosed in 302 (53.5%) patients. ICU care was required for 140 (24.8%) patients and mechanical ventilation for 135 (23.9%). Overall, 393 (69.6%) improved clinically and survived to discharge.

The in-hospital CFR was 30.4% (172/565). Patients who died were older (mean [SD] age, 70.4 [14.0] years vs 61.8 [16.4] years, P < 0.0001) than patients who survived. The chi-squared test for trend showed a linear trend of increasing mortality by increase in age group. Males were more likely to die (99 [57.6%] vs 73 [42.4%]; P = 0.08) than females. There was no association between race and mortality (P = 0.19) (Table 1).

Patients who died were more likely to have congestive heart failure (20.3% vs 12.0%; P = 0.009), dementia (27.3% vs 12.2%; P < 0.0001), hemiplegia (10.5% vs 4.8%; P = 0.01) and a diagnosis of malignancy (9.3% vs 4.6%; P = 0.03). The mean duration of symptoms prior to the hospitalization was shorter for patients who died compared to those survived (4.8 ± 4.1 vs 5.5 ± 4.1; P = 0.05). Among patients who died, 44.2% were confused on presentation compared to 21.1% of those who survived (P < 0.0001). Mean qSOFA score were significantly higher among patients who died compared to those who survived.

Patients who died from COVID-19 infection demonstrated an increased inflammatory response, including higher mean white blood cell counts (WBCs) (× 10⁹ per L [SD] 8.6 [4.3] vs 7.5 [3.8]; P = 0.005), lower absolute lymphocyte counts (× 10⁹ per L [SD] 1.0 [0.7] vs 1.2 [0.6]; P = 0.003), and increased C-reactive protein (CRP) levels (mean [SD] 130.0 [92.4] vs 88.1 [73.3]; P < 0.0001) compared with patients who survived. Patients who died had significantly elevated procalcitonin and troponin levels on admission; however, these patients also had acute renal injury on admission which may explain these findings.

Patients who died were intubated sooner (Median [IQR] 22.3 [101.3] vs 45.2 [69.5] hours; P = 0.8) than who survived. Use of azithromycin, hydroxychloroquine and steroids was significantly higher among patients who died than survived. The CFR among patients requiring intubation and patients admitted to ICU was 77.0% and 75.7%, respectively (Table 2).

From the univariable analysis in Table 1, we identified each variable that showed and/or reached statistical significance with P < 0.09 between patients who were discharged versus those who died. The CWIC score was used in the model instead of separate comorbidities. For multivariable logistic regression, variables initially entered the model included age ≥ 60 yrs., sex, CWIC, median income, hospital admission source, hypertension, qSOFA score, WBC counts on admission, lymphocytopenia on admission, creatinine on admission, and aspartate aminotransferase (AST) on admission, total protein on admission, albumin on admission, and abnormal chest x-ray on admission. After 8 iterations, the model with the lowest -2 log likelihood value included 8 variables that were associated with the odds of death from COVID-19 infection, including patient age (≥ 60 yrs.), higher CWIC score, higher qSOFA score, higher WBC counts on admission, lower albumin on admission, elevated AST, lymphocytopenia, and thrombocytopenia on admission (Table 3).

**Discussion**

In our study, the CFR was 30.4%, similar to the 30.9% CFR reported from Georgia (U.S.).19 Our institution noted an early surge of COVID-19 cases like New York, when ventilatory and other therapeutic interventions were evolving.20 Nearly 40% of studied patients were transitioned to comfort care, and the predominantly older cohort also may explain the high mortality seen in our study. In addition, our population included 30% of patients from nursing facilities who had worse prognosis. Lower mortality rates have been reported in early studies from different countries but recent data from various US cohorts demonstrate a mortality range from 21% to 67%.6,7,9,10,19-25 Risk factors for death in our study generally were consistent with prior data other than obesity and race which were not associated with mortality.

Age was also an independent risk factor for death in our study, which confirms prior reports. An early study from China reported higher mortality in older age groups.6 Another study also found significantly higher mortality in patients ≥ 64 years old compared with younger patients (36% vs 15%; P < .001).26 Early U.S. epidemiologic data suggest that the case fatality is highest in persons aged ≥ 85 years (range 10%-27%), followed by 3% to 11% for ages 65 to 84 years.11 Poorer outcomes in the elderly may result from immunosenescence and immune dysregulation leading to insufficient immunologic or overexuberant inflammatory responses.

Similar to the findings of Ebben et al., a higher CWIC score was an independent predictor of mortality in our study.22 In particular, congestive heart failure, dementia, hemiplegia, malignancy, and severe liver disease were associated with mortality. Chinese studies have also previously reported high mortality in patients with comorbidities (10.5% for cardiovascular disease, 7.3% for diabetes, 6.3% for chronic respiratory disease, 6% for hypertension, and 5.6% for cancer).6 Another study reported a 28% CFR overall among patients with malignancies, 37% among hematological malignancies, and 25% among solid organ malignancies.27 The effect of multiple comorbidities (≥ 2) was synergistic, leading to a mortality of 15.4% compared to 5.6% in patients with one comorbidity.28

In our study, the qSOFA at the time of hospitalization was an independent predictor for in-hospital mortality from COVID-19. The qSOFA score was introduced by Third International Consensus Definitions for Sepsis and Septic Shock (Sepsis-3) task force and its use was associated with a greater prognostic accuracy for in-hospital mortality compared to
Table 1. Univariable Analysis of Predictors for Death From COVID-19 Infection.

| Characteristic                              | Survivors (n = 393) (%) | Died (n = 172) (%) | OR (95% CI) | P value |
|---------------------------------------------|-------------------------|--------------------|-------------|---------|
| **Age groups, years**                       |                         |                    |             |         |
| <60                                         | 178 (45.3)              | 36 (20.9)          | 3.1 (2.1, 4.7) | <0.0001 |
| ≥60                                         | 215 (54.7)              | 136 (79.1)         |             |         |
| **Age quartiles, years, n (%)**             |                         |                    |             |         |
| <53                                         | 117 (29.8)              | 19 (11.0)          |             | <0.0001 |
| 53-65.9                                     | 105 (26.7)              | 38 (22.1)          |             |         |
| 66-74.9                                     | 83 (21.1)               | 47 (27.3)          |             |         |
| ≥75                                         | 88 (22.4)               | 68 (39.5)          |             |         |
| **Sex, n (%)**                              |                         |                    |             |         |
| Male                                        | 195 (49.6)              | 99 (57.6)          | 1.4 (1.0, 2.0) | 0.08    |
| Female                                      | 198 (50.4)              | 73 (42.4)          |             |         |
| **Race, n (%)**                             |                         |                    |             |         |
| White                                       | 73 (18.7)               | 42 (24.4)          |             | 0.19    |
| Black                                       | 308 (78.8)              | 128 (74.4)         |             |         |
| Other                                       | 10 (2.6)                | 2 (1.2)            |             |         |
| **BMI, mean ± SD**                          | 32.4 ± 8.5              | 31.1 ± 10.1        |             | 0.14    |
| **Median income, mean ± SD**                | 36477.1 ± 14926.7       | 39131.9 ± 17013.2  |             | 0.07    |
| **Admission source**                        |                         |                    |             |         |
| Home                                        | 297 (75.6)              | 99 (57.6)          | 2.3 (1.6, 3.3) | <0.0001 |
| Nursing facility                            | 96 (24.4)               | 73 (42.4)          |             |         |
| **Comorbidities, n (%)**                    |                         |                    |             |         |
| ≥one comorbidity                            | 370 (94.1)              | 168 (97.7)         | 2.6 (0.9, 7.7) | 0.07    |
| Myocardial infarction                       | 28 (7.1)                | 13 (7.6)           | 1.1 (0.5, 2.1) | 0.86    |
| Congestive heart failure                    | 47 (12.0)               | 35 (20.3)          | 1.9 (1.2, 3.0) | 0.009   |
| Peripheral vascular disease                 | 27 (6.9)                | 11 (6.4)           | 0.9 (0.5, 1.9) | 0.84    |
| Cerebrovascular disease                     | 61 (15.6)               | 25 (14.5)          | 0.9 (0.6, 1.5) | 0.76    |
| Dementia                                    | 48 (12.2)               | 47 (27.3)          | 2.7 (1.7, 4.2) | <0.0001 |
| Chronic pulmonary disease                   | 83 (21.9)               | 43 (25.0)          | 1.2 (0.8, 1.8) | 0.42    |
| Connective tissue disease                   | 6 (1.5)                 | 5 (2.9)            | 1.9 (0.6, 6.4) | 0.28    |
| Peptic ulcer disease                        | 12 (3.1)                | 6 (3.5)            | 1.1 (0.4, 3.1) | 0.79    |
| Diabetes                                    | 148 (37.7)              | 71 (41.3)          | 1.2 (0.8, 1.7) | 0.42    |
| Hemiplegia                                  | 18 (4.8)                | 18 (10.5)          | 2.3 (1.2, 4.5) | 0.013   |
| Renal disease                               | 64 (16.3)               | 36 (20.9)          | 1.4 (0.9, 2.1) | 0.19    |
| Any malignancy                              | 18 (4.6)                | 16 (9.3)           | 2.1 (1.1, 4.3) | 0.03    |
| Metastatic solid tumor                      | 7 (1.8)                 | 5 (2.9)            | 1.7 (0.5, 5.3) | 0.39    |
| Mild liver disease                          | 7 (1.8)                 | 4 (2.3)            | 1.3 (0.4, 4.5) | 0.67    |
| Moderate-severe liver disease               | 1 (0.3)                 | 4 (2.3)            | 9.3 (1.0, 84.1) | 0.02    |
| AIDS                                        | 3 (0.8)                 | 0 (0.0)            |             |         |
| Median CWIC (25th, 75th)                    | 1 (0.2)                 | 2 (1.3)            |             | <0.0001 |
| Hypertension                                | 282 (71.8)              | 136 (79.1)         | 1.5 (1.0, 2.3) | 0.07    |
| Current tobacco smoker                      | 25 (6.4)                | 12 (7.1)           | 1.1 (0.5, 2.3) | 0.76    |
| Obesity                                     | 216 (56.0)              | 84 (49.1)          | 0.8 (0.5, 1.1) | 0.14    |
| Morbid obesity                              | 75 (19.4)               | 30 (17.5)          | 0.9 (0.6, 1.4) | 0.60    |
| **Symptoms, n (%)**                         |                         |                    |             |         |
| Fever                                       | 227 (58.4)              | 87 (51.2)          | 0.7 (0.5, 1.1) | 0.12    |
| Shortness of breath                         | 271 (69.7)              | 129 (76.3)         | 1.4 (0.9, 2.1) | 0.11    |
| Altered mental status                       | 83 (21.1)               | 76 (44.2)          | 3.0 (2.0, 4.4) | <0.0001 |
| **Vitals on admission**                     |                         |                    |             |         |
| Systolic BP, mean ± SD                      | 133.9 ± 24.8            | 132.7 ± 28.0       | 0.65        |         |
| Systolic BP on admission                     |                         |                    |             |         |
| >100 mmHg                                   | 365 (92.9)              | 147 (85.5)         | 2.2 (1.3, 3.9) | 0.005   |
| <100 mmHg                                   | 28 (7.1)                | 25 (14.5)          |             |         |
| Diastolic BP, mean ± SD                     | 75.0 ± 17.4             | 73.6 ± 18.1        | 0.36        |         |
| Heart rate, mean ± SD                       | 99.0 ± 21.7             | 104.6 ± 22.9       | 0.006       |         |
| Respiratory rate on admission               |                         |                    |             |         |
| <22 breaths per minute                      | 217 (55.2)              | 59 (34.3)          | 2.4 (1.6, 3.4) | <0.0001 |
| ≥22 breaths per minute                      | 176 (44.8)              | 113 (65.7)         |             |         |
either systemic inflammatory response syndrome (SIRS) or severe sepsis. We previously showed that bedside qSOFA score at the time of hospitalization can predict in-hospital mortality among adults 65 years with COVID-19 after adjusting for CWIC score and thrombocytopenia. In that study, for patients with qSOFA score of 0, 1, 2 and 3 at the time of hospital admission, the mortality rates were 8.7%, 19.7%, 41.7% and 60%, respectively. An early study from China noted higher SOFA scores on admission were associated with a higher odds of in-hospital death. There is limited information on qSOFA as a predictor of mortality. We found admission qSOFA to be an independent predictor for in-hospital mortality from COVID-19 regardless of age. Elevated respiratory rate, low oxygen saturation and need for oxygenation at the time of hospitalization have been associated with severe diseases and poor outcomes.

### Table 1. (continued)

| Characteristic                        | Survivors (n = 393) (%) | Died (n = 172) (%) | OR (95% CI)   | P value |
|--------------------------------------|-------------------------|--------------------|---------------|---------|
| Fever, n (%)                         | 137 (34.9)              | 75 (43.6)          | 1.5 (1.0, 2.1) | 0.05    |
| Oxygen saturation, mean ± SD         | 0.95 ± 0.06             | 0.92 ± 0.08        | <0.0001       |
| Mean qSOFA score                     | 0.73 ± 0.69             | 1.24 ± 0.81        | <0.0001       |
| Abnormal chest x-ray on admission, n (%) | 283 (72.2)             | 140 (81.4)         | 1.7 (1.1, 2.6) | 0.02    |

| Laboratory findings on admission, n (%) |
|-----------------------------------------|
| Leukopenia                              | 44 (11.2)               | 16 (9.3)           | 0.8 (0.4, 1.5) | 0.50    |
| Lymphocytopenia                         | 172 (47.0)              | 104 (61.2)         | 1.9 (1.3, 2.7) | 0.001   |
| Thrombocytopenia                        | 67 (17.2)               | 50 (29.2)          | 2.0 (1.3, 3.0) | 0.001   |
| Elevated AST (>40 U/L)                  | 191 (51.8)              | 108 (67.5)         | 1.9 (1.3, 2.9) | 0.001   |
| Elevated ALT (>40 U/L)                  | 130 (34.3)              | 46 (27.7)          | 0.7 (0.5, 1.1) | 0.13    |
| Low serum proteins (<6.2 gm/dl)         | 26 (6.8)                | 23 (13.9)          | 2.2 (1.2, 4.0) | 0.004   |
| Low serum albumin (<3.5 gm/dl)          | 148 (38.8)              | 110 (66.3)         | 3.1 (2.1, 4.5) | <0.0001 |
| Elevated serum LDH (>500 U/L)          | 46 (19.6)               | 38 (38.8)          | 2.6 (1.5, 4.3) | <0.0001 |
| Elevated serum ferritin (>1000 ng/ml)  | 90 (35.9)               | 52 (45.6)          | 1.5 (1.0, 2.4) | 0.08    |
| Elevated D dimer (>1500 mg/ml)         | 73 (50.3)               | 51 (75.7)          | 3.1 (1.6, 5.7) | <0.0001 |
| Elevated troponin (>0.05 mg/ml)        | 50 (18.1)               | 43 (38.1)          | 2.9 (1.7, 4.5) | <0.0001 |
| Elevated CRP (>10 mg/L)                | 332 (91.0)              | 140 (95.3)         | 2.1 (0.9, 4.9) | 0.07    |
| Elevated creatinine (from baseline)    | 134 (35.3)              | 88 (55.3)          | 2.3 (1.6, 3.3) | <0.0001 |

| Clinical diagnosis, n (%)               |
|-----------------------------------------|
| Uncomplicated COVID19 illness           | 203 (51.7)              | 60 (34.9)          | <0.0001      |
| Mild COVID-19 infection                 | 136 (34.6)              | 61 (35.5)          | <0.0001      |
| Severe COVID-19 infection               | 54 (13.7)               | 51 (29.7)          | <0.0001      |

### Table 2. Outcome of COVID-19 Infected Patients.

| Complications, n (%) | Survivors (n = 393) (%) | Died (n = 172) (%) | OR (95% CI)   | P value |
|----------------------|-------------------------|--------------------|---------------|---------|
| Mechanical intubation | 31 (7.9)                | 104 (60.5)         | 17.9 (11.1, 28.8) | <0.0001 |
| Time to intubation   |                         |                    |               |         |
| <24 hrs. from hospital admission | 14 (45.2)              | 55 (52.9)          | 0.7 (0.3, 1.6) | 0.45    |
| >24 hrs. from hospital admission | 17 (54.8)              | 47 (47.1)          |               |         |
| ICU admission        | 34 (8.7)                | 106 (61.6)         | 17.0 (10.6, 27.1) | <0.0001 |
| Septic shock         | 8 (2.0)                 | 64 (37.2)          | 28.4 (13.2, 61.1) | <0.0001 |
| ARDS                 | 11 (2.8)                | 41 (23.8)          | 10.9 (5.4, 21.8) | <0.0001 |
| Acute renal injury   | 120 (30.5)              | 114 (66.3)         | 4.5 (3.1, 6.6) | <0.0001 |
| DIC                  | 1 (0.3)                 | 3 (1.7)            | 6.9 (0.7, 67.4) | 0.05    |
| Rhabdomyolysis       | 12 (3.1)                | 7 (4.1)            | 1.3 (0.5, 3.5) | 0.55    |
| Need for RRT         | 6 (1.5)                 | 18 (10.6)          | 7.6 (3.0, 19.6) | <0.0001 |
| Azithromycin given   | 214 (54.6)              | 115 (67.3)         | 1.7 (1.2, 2.5) | 0.005   |
| Hydroxychloroquine   | 223 (56.7)              | 133 (77.3)         | 2.6 (1.7, 3.9) | <0.0001 |
| Steroids             | 158 (40.2)              | 125 (72.7)         | 4.0 (2.7, 5.9) | <0.0001 |

Abbreviations: n, number; OR, odds ratio; CI, confidence interval; BMI, body mass index; SD, standard deviation; AIDS, acquired immunodeficiency syndrome; CWIC, Charlson weighted index of comorbidity; BP, blood pressure; ACEI, angiotensin converting enzyme inhibitor; ARBs, angiotensin II receptor blockers; AST, aspartate aminotransferase; ALT, alanine aminotransferase; LDH, lactate dehydrogenase; CRP, C-reactive protein; qSOFA, quick sepsis related organ failure assessment.
Our study showed an inverse relationship between the level of albumin and the risk of death in COVID-19 patients. This result is consistent with a previous study reporting hypoalbuminemia associated with the COVID-19-related complications including death. It had been noted that decrease in albumin does not parallel the severity of hepatocellular injury in COVID-19, suggesting that there are other mechanisms involved for hypoalbuminemia in severe COVID-19. In a recently published article, the low albumin was considered as a predictor of mortality in COVID-19. A possible additional explanation was that the oxidative stress impairs the antioxidant property of the albumin and elicits cell and tissue damage.

A research study conducted in China, assessed the association between markers of liver injury and mortality in COVID-19 patients. It was found that AST elevation upon hospital admission was positively associated with the increase of neutrophil counts and the decrease of lymphocyte counts at baseline. We now know that both neutrophilia and lymphopenia are indicators of disease severity. In our study, AST was associated with increased mortality, similar finding with European study where liver enzyme elevations were associated with increased mortality, similar finding with a previous study reporting hypoalbuminemia in severe COVID-19.

We also found that WBC counts, lymphocytopenia, and thrombocytopenia at the time of hospital admission were independent predictors for in-hospital mortality. In our cohort, lymphocytopenia was more frequent in patients who died versus those who survived (62.5% vs 46.9%). A systematic review and meta-analysis showed that patients who died had lower lymphocyte count (mean difference — 395.35 μL [−165.64,−625.07], P < 0.001). Thrombocytopenia has been linked with severe COVID-19 complications including death.

Non-survivors have been reported to have higher WBC counts than survivors, which is thought to be compensatory for a drop in other bloodlines. Our study has several limitations. This was a single institution study of admitted patients which makes generalization difficult. Because of the retrospective design, certain laboratory results were sometimes unavailable for some patients, including lactate dehydrogenase, d dimer, and serum ferritin. Patients with chronic lung disease and conditions associated with immunosuppression were only a small percentage among hospitalized patients. Therefore, the role of some of these variables in predicting mortality from COVID-19 infection could have been underestimated. Finally, a predominantly black and obese cohort may limit the generalizability of some findings (for e.g.: race). Nonetheless, our study involved a population of black patients in Detroit MI, a state that had the highest case-fatality rate in the United States at an early phase of pandemic. These data may provide valuable information on the risk factors for mortality in this population.

### Conclusions
Our study showed a mortality of 30.4% among hospitalized patients due to COVID-19 infection. Independent factors associated with in-hospital mortality were age ≥60 years, CWIC score, qSOFA score at the time of hospitalization, admission WBC, serum albumin, AST, lymphocytopenia, and thrombocytopenia at the time of admission. Recognizing the population at highest risk for severe COVID-19 related outcomes may guide and result in aggressive supportive care and treatment interventions.

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