Characteristics Associated With Disparities Among Older Adults in Coronavirus Disease 2019 Outcomes in an Academic Health Care System

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Background: An improved understanding of the coronavirus disease 2019 (COVID-19) pandemic is needed to identify predictors of outcomes among older adults with COVID-19.

Objective: The objective of this study was to examine patient and health system factors predictive of in-hospital mortality, intensive care unit (ICU) admission, and readmission among patients with COVID-19.

Design, Setting, and Participants: A cohort study of patients aged 18 years and older with COVID-19 discharged from 5 New York hospitals within the Mount Sinai Health System (March 1, 2020–June 30, 2020).

Measures: Patient-level characteristics (age, sex, race/ethnicity, co-morbidities/serious illness, transfer from skilled nursing facility, severe acute respiratory syndrome coronavirus 2 viral load, Sequential Organ Failure Assessment score, treatments); hospital characteristics.

Outcomes: All-cause in-hospital mortality; ICU admission; 30-day readmission.

Results: Among 7556 subjects, mean age 61.1 (62.0) years; 1556 (20.6%) died, 949 (12.6%) had an ICU admission, and 227 (9.1%) had a 30-day readmission. Increased age [aged 55–64: odds ratio (OR), 3.28; 95% confidence interval (CI), 2.41–4.46; aged 65–74: OR, 4.67; 95% CI, 3.43–6.35; aged 75–84: OR, 10.73; 95% CI, 7.77–14.81; aged 85 y and older: OR, 20.57; 95% CI, 14.46–29.25] and comorbidities (OR, 1.11; 95% CI, 1.16, 2.13) were independent risk factors for in-hospital mortality. Yet older adults (aged 55–64 y: OR, 0.56; 95% CI, 0.40–0.77; aged 65–74: OR, 0.46; 95% CI, 0.33–0.65; aged 75–84: OR, 0.27; 95% CI, 0.18–0.40; aged above 85 y: OR, 0.21; 95% CI, 0.13–0.34) and those with Medicaid (OR, 0.74; 95% CI, 0.56–0.99) were less likely to be admitted to the ICU. Race/ethnicity, crowding, population density, and health system census were not associated with study outcomes.

Conclusions: Increased age was the single greatest independent risk factor for mortality. Comorbidities and serious illness were in-dependently associated with mortality. Understanding these risk factors can guide medical decision-making for older adults with COVID-19. Older adults and those admitted from a skilled nursing facility were half as likely to be admitted to the ICU. This finding requires further investigation to understand how age and treatment preferences factored into resource allocation.

Key Words: older adults, COVID-19, mortality, ICU admission

The first surge of the severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) pandemic created un-precedented numbers of adults presenting to emergency de-partments (EDs). By May 1, 2020, 164,505 patients[1] had been hospitalized with coronavirus disease 2019 (COVID-19) across New York City (NYC), and 13,000 died.[2]

Early reports identified age over 65 years, male sex, chronic comorbidities (obesity, diabetes, and hypertension), and serious illnesses [cancer,[3] chronic obstructive pulmonary disease (COPD), and dementia].[4–8] As the US pandemic progressed, other high-risk populations emerged including skilled nursing facility (SNF) residents,[9,10] persons of lower socioeconomic status, and persons of color.[11,12] Potential explanatory factors for these findings including alternation in immune function (eg, cancer); impaired lung function (eg, COPD, obesity); communal living environments, close con-tact care, and limited personal protective equipment (eg, SNF residents); and increased population density and crowding[13]

leading to greater viral transmission and viral load[3] (eg, persons of lower economic status).[3,14,15]

Whereas age has emerged consistently as a risk factor, the extent to which age itself is an independent risk factor for adverse COVID outcomes (eg, mortality) when other conditions (eg, comorbid illness,[8] crowding, population density, viral load) are accounted for has not been studied. To better understand morbidity and mortality risk among older adults, we utilized electronic health record (EHR) data, billing data, and postacute care transition data from 5 diverse hospital EDs in a single, large, urban health system to examine how key factors were associated with all-cause in-hospital mortality, intensive care unit (ICU) admission and 30-day readmission.

METHODS

Analytic File and Data Sources

We utilized a constructed analytic file of ED and hospital encounters of people with COVID-19 with a discharge date between March 1, 2020, and June 30, 2020, by linking data from EHR (EPIC-version August 2019), administrative billing data (MSX), Mount Sinai Pathology laboratory data, and SNF-to-hospital transition data (CarePort) for 5 Mount Sinai Health System ED/hospitals in NYC. The hospitals included two 100-bed community hospitals, 1 large quaternary care medical center, and 2 mid-size 330-bed community hospitals. Three hospitals were excluded because they did not share the same EHR. In addition to patient's health data, the EHR included a flag for COVID infection and the nasopharyngeal polymerase chain reaction (PCR) SARS-CoV-2 results; billing data included *International Classification of Diseases, 10th Revision* (ICD-10) codes for each encounter and the ED, hospital, and ICU daily census. Neighborhood-level measures, including crowding, defined as the percentage of households with ≥ 1 occupant per room, and population density,[13] using *2018 American Community Survey: 5-Year Data (2014–2018)*, were included in the analytic file at the census tract level.

The study was approved by the Icahn School of Medicine at Mount Sinai Institutional Review Board.

Sample

We identified patients (n = 7556) with an ED or hospital encounters with a date of discharge between March 1, 2020, and June 30, 2020, of persons aged 18 years and older with: (1) an ICD-10 diagnosis of COVID (if they were discharged after April 1, 2020); (2) a PCR-confirmed SARS-CoV-2 infection during the encounter; and (3) with or without an EHR COVID-19 flag. Because the patient was our unit of analysis, we used the first admission during the study period as an "index" admission and subsequent hospitalizations as "readmissions." We excluded patients who were admitted to labor and delivery, pediatrics, neonatology, psychiatry, rehabilitation, or hospice (n = 331), for elective procedures with a prior PCR-confirmed SARS-CoV-2 infection, confirmed by chart review (n = 45), and those with missing covariates (n = 730) (Fig. 1).

Outcome

Our primary outcome was death due to any cause during the ED/hospital encounter for a PCR-confirmed SARS-CoV-2 infection. Mortality was ascertained from the EHR. Our secondary outcomes were ICU admission and 30-day readmission, both of which were collected from billing data. In-hospital mortality, ICU admission, and hospital readmission were selected as outcomes because they reflect key utilization points during the illness trajectory of patients.

Variables

We collected data on a priori selected factors in clinically meaningful domains including demographic (age, sex, and race/ethnicity) and socioeconomic characteristics (Medicaid, household crowding, and population density). The population density variable was included to account for differences in population density by neighborhood, and the crowding variable to account for the difference in the number of individuals living in discrete homes. Using the census tract in which the patient resided, we measured crowding by the percent of households with >1 occupant per room and population density as the total population, categorized by quartiles.[13,16,17]

We used ICD-10 codes to calculate the unweighted Elixhauser Comorbidity Index,[18,19] which counts 30 comorbidities including key risk factors for severe COVID such as diabetes, hypertension, and obesity. We also used ICD-10 codes to identify serious illnesses and leading causes of death in the United States, including cancer, COPD, dementia, and coronary artery disease (CAD).[20,21] To capture the severity of illness, we included the worst Sequential Organ Failure Assessment (SOFA) Score in the first 7 days of presentation.[22–24] We included receipt of treatments during the ED/hospital encounter, such as dexamethasone,[25] the mutually exclusive maximal oxygen support received (nasal cannula, high-flow nasal cannula, bilevel positive airway pressure, or ventilator), and ICU admission. To account for clinical volume, we collected daily site-specific ED, ICU, and hospital census. We linked ED and hospital encounters using ED discharge disposition and linked encounters during which patients were moved between hospital sites using EHR transfer flags. We determined if patients were transferred from a SNF prior the encounter using SNF data. The viral pathology data included SARS-CoV-2 viral RNA load at admission. The viral load was measured using nasopharyngeal swab samples for SARS-CoV-2. Only those specimens with a cycle threshold < 38 were considered as positive tests. Viral loads were calculated with standard curves.[15,26]

Statistical Analysis

Our goal was to examine how factors in the domains of sociodemographics, clinical severity, and health system are associated with risk of death, ICU admission, and 30-day readmission. To examine risk factors, we conducted bivariable analyses of the entire sample and among those 65 years of age and older. We used multivariable logistic regression to identify factors associated with in-hospital mortality, ICU admission, and 30-day readmission. We used generalized logistic regression models to estimate marginal effects for each explanatory variable at the mean value of other predictor variables in the model.
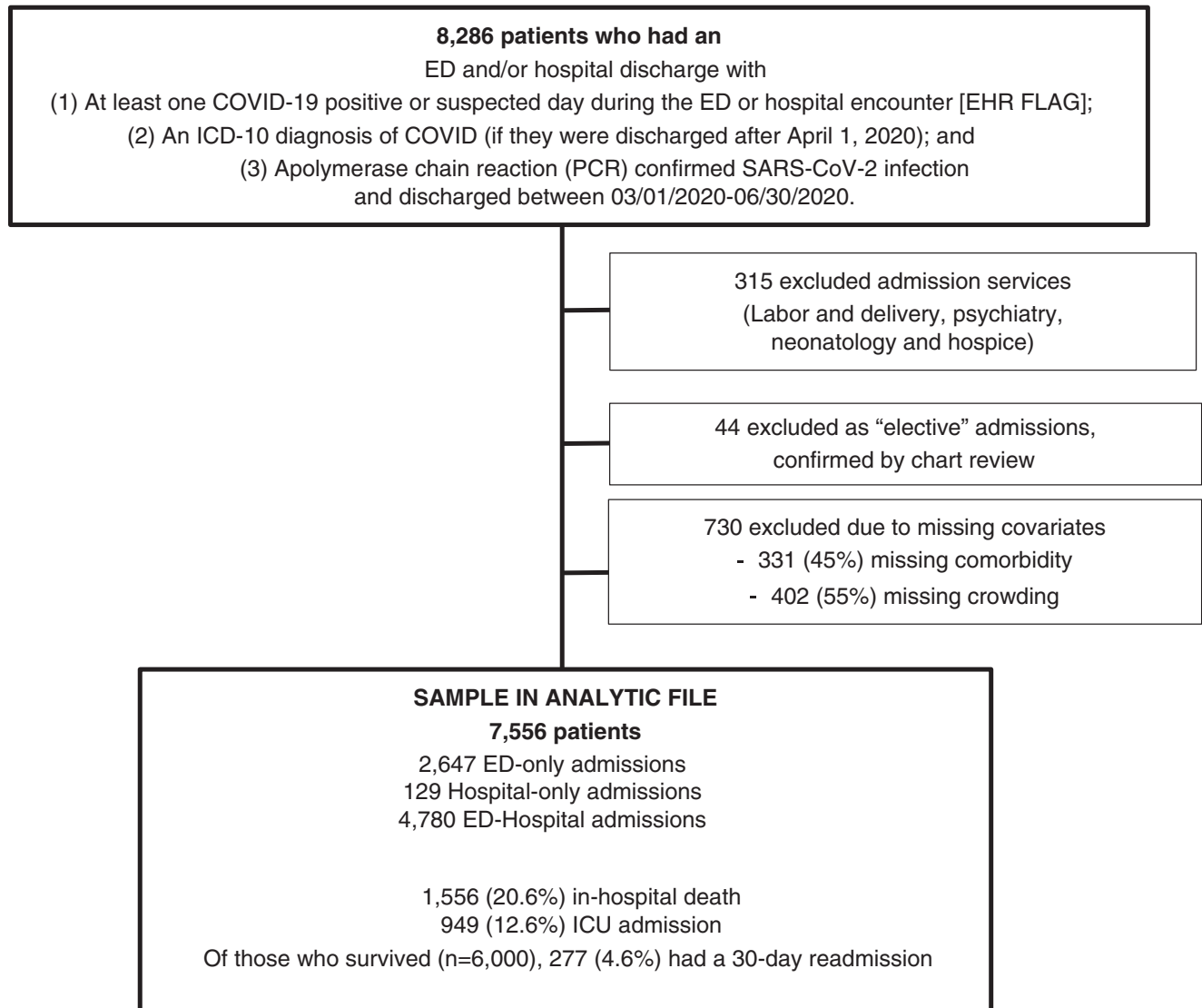
8,286 patients who had an
ED and/or hospital discharge with
(1) At least one COVID-19 positive or suspected day during the ED or hospital encounter [EHR FLAG];
(2) An ICD-10 diagnosis of COVID (if they were discharged after April 1, 2020); and
(3) Apolymerase chain reaction (PCR) confirmed SARS-CoV-2 infection
and discharged between 03/01/2020-06/30/2020.

315 excluded admission services
(Labor and delivery, psychiatry,
neonatology and hospice)

44 excluded as "elective" admissions,
confirmed by chart review

730 excluded due to missing covariates
- 331 (45%) missing comorbidity
- 402 (55%) missing crowding

SAMPLE IN ANALYTIC FILE
7,556 patients
2,647 ED-only admissions
129 Hospital-only admissions
4,780 ED-Hospital admissions

1,556 (20.6%) in-hospital death
949 (12.6%) ICU admission
Of those who survived (n=6,000), 277 (4.6%) had a 30-day readmission

FIGURE 1. Study selection flowchart. COVID-19 indicates coronavirus disease 2019; ED, emergency department; EHR, electronic health record; ICD-10, *International Classification of Diseases, 10th Revision*; SARS-CoV-2, severe acute respiratory syndrome coronavirus 2.

To assess the association of study factors with the risk of death among the subgroup of older adults, we used multivariable logistic regression to identify factors associated with in-hospital mortality among those aged 65 years and older and generalized logistic regression models to estimate marginal effects. Because we were interested in estimating the variation by hospital site, we did not include a multilevel model clustered on the hospital. Finally, we estimated the predicted percentage of the population with each outcome (in-hospital mortality, ICU admission, and 30-d readmission).

Data were analyzed using Stata MP, version 161.1 (StataCorp).

Secondary Analyses

We repeated our multivariable analyses with the subsample of patients for whom we had viral load data (n = 4275) to identify the potential relevance of viral load data at the time of admission and its association with mortality. To conduct a sensitivity analysis of the effect of viral load as a predictor, we ran the mortality model within in this sample, both with and without the viral load predictor (Supplemental Table 1, Supplemental Digital Content 1, http://links.lww.com/MLR/C409).

Sensitivity Analysis

We examined characteristics of the sample (n = 730) with missing covariates and conducted bivariate comparisons with the sample included in our analysis (Supplemental Table 2, Supplemental Digital Content 2, http://links.lww.com/MLR/C410). Of these excluded 730 patients due to missing covariates, 331 (45%) had missing comorbidity count, and 402 (55%) had missing data on crowding.

RESULTS

We identified 7556 patients with ED or hospital encounters, patients [3857 women (44.9%); mean age: 61.0 (62.0) y; and 1823 White (21.2%), 2533 Black (29.5%), 2017 Latinx (23.5%), and 2214 (25.8%) other races/ethnicities] with confirmed ED and/or hospital encounter for SARS-CoV-2 infection. Overall, 1556 (21%) patients died in the hospital, 949 (13%) had an ICU admission, and of those encounters with a live discharge (n = 6000), 277 (4.6%) had 30-day readmission. Patient and health system characteristics are described in Table 1. We included a Supplemental Table describing the characteristics of the 5 hospitals included in the study, including monthly COVID cases and ICU occupancy during this period (Supplemental Table 3, Supplemental Digital Content 3, http://links.lww.com/MLR/C411). We found no clinically meaningful differences between the overall sample and those excluded due to missing covariates (Supplemental Table 2, Supplemental Digital Content 2, http://links.lww.com/MLR/C410).

Primary Outcome: All-cause Mortality in Patients Presenting to the Emergency Department/Hospital With Coronavirus Disease 2019

Age and Mortality

The multivariable associations between patient and health system characteristics and in-hospital mortality among those aged 18 years and older (n = 7556) and those aged 65 years and older (n = 3433) are shown in Table 2. Predicted percentage of mortality varied from 9.8% for those aged below 55 years, 16.9% for those aged 55–64 years, 19.7% for those aged 65–74 years, 28.0% for those aged 75–84 years, and 36/3% for those aged above 85 years (Fig. 2). Similarly, in the subsample of patients aged 65 years and above (n = 3871), each decade of older age, relative to those aged 65–74 years, was associated with a higher probability of mortality [aged 75–84 y: odds ratio (OR), 2.39; 95% confidence interval (CI), 1.87–3.05; aged above 85 y: OR, 4.54; 95% CI, 3.43–6.00].

Additional Predictors of Mortality

Increased number of comorbidities was associated with a higher probability of mortality in the overall sample (OR, 1.11; 95% CI, 1.16–2.13). Independent of comorbidities, serious illnesses were also associated with a higher probability of mortality [cancer (OR, 4.32; 95% CI, 2.72–6.85), COPD (OR, 3.63; 95% CI, 2.95–4.47), dementia (OR, 1.53; 95% CI, 1.20–1.94), and CAD (OR, 1.35; 95% CI, 1.13–1.62)].

Other significant predictors included admission from a SNF (OR, 1.57; 95% CI, 1.16–2.13), worse SOFA scores within first 7 days of presentation [mortality 15%–50% (OR, 4.10; 95% CI, 3.08–5.47); mortality > 50% (OR, 36.05; 95% CI, 21.86–59.44)], and level of oxygen support required [nasal cannula (OR, 0.59; 95% CI, 0.47–0.74); high-flow nasal cannula (OR, 4.19; 95% CI, 2.91–6.05); bilevel positive airway pressure (OR, 9.31; 95% CI, 6.93, 12.50); and ventilator (OR, 8.87; 95% CI, 6.49–12.13)]. Patients admitted earlier in the pandemic had a higher probability of mortality than those admitted near the pandemic's start [April (OR, 0.42; 95% CI, 0.32–0.56); May (OR, 0.11; 95% CI,

TABLE 1. Demographic, Clinical, and Health System Characteristics of Patients Who Presented With COVID-19 at Mount Sinai Health System (MSHS)

Demographic, Clinical and Health System Characteristics	Total Sample (n = 7556)	Age ≥ 65 Years (n = 3433)
Sociodemographic characteristics		
Age (y)		
Mean (median)	61.1 (62.0)	77.2 (76.0)
< 55	2558 (33.9)	—
55–64	1565 (20.7)	—
65–74	1543 (20.4)	1543 (44.9)
75–84	1126 (14.9)	1126 (32.8)
≥ 85	764 (10.1)	764 (22.3)
Female	3423 (45.3)	1670 (48.6)
Race/ethnicity		
White	1610 (21.3)	960 (28.0)
Black	2230 (29.5)	951 (27.7)
Latinx	1720 (22.8)	774 (22.5)
Other	1996 (26.4)	748 (21.8)
Medicaid	1411 (18.7)	225 (6.6)
Clinical markers of illness severity		
Elixhauser Comorbidity Index [mean (median)]	2.3 (2.0)	3.2 (3.0)
Serious illnesses		
Cancer	151 (2.0)	93 (2.7)
COPD	3361 (44.5)	2078 (60.5)
Dementia	688 (9.1)	657 (19.1)
CAD	1842 (24.4)	1405 (40.9)
Predicted mortality (worst SOFA in first 7 d of encounter)		
< 10%	6628 (87.7)	2882 (83.9)
15%–50%	622 (8.2)	371 (10.8)
> 50%	306 (4.0)	180 (5.2)
Viral load [mean (median)] (mL)	10.4 (11.5)	10.8 (12.4)
Community-level factors		
Crowding [mean (median)]*	9.1 (7.2)	8.5 (6.4)
Treatments received		
Dexamethasone	168 (2.2)	84 (2.4)
Maximal oxygen support received		
No oxygen support	4109 (54.4)	1408 (41.0)
Nasal cannula	1891 (25.0)	1050 (30.6)
High-flow nasal cannula	247 (3.3)	157 (4.6)
BiPAP	502 (6.6)	346 (10.1)
Ventilator	807 (10.7)	472 (13.7)
Health system factors		
Hospital site		
Mount Sinai (A)	2434 (32.2)	984 (28.7)
Mount Sinai (B)	1728 (22.9)	780 (22.7)
Mount Sinai (C)	1380 (18.3)	648 (18.9)
Mount Sinai (D)	1290 (17.1)	672 (19.6)
Mount Sinai (E)	724 (9.6)	349 (10.2)
Discharge month		
March	1999 (26.5)	542 (15.8)
April	4371 (57.8)	2283 (66.5)
May	897 (11.9)	474 (13.8)
June	289 (3.8)	134 (3.9)
SNF resident admission	372 (4.9)	330 (9.6)
Outcomes		
Death	1556 (20.6)	1170 (34.1)
ICU admission	949 (12.6)	496 (14.4)
30-d readmission	277 (4.6)	160 (10.0)

*Crowding is measured as the mean (median) number of households within the census tract who met crowding definition (ie, percentage of households with > 1 occupant per room).

BiPAP indicates bilevel positive airway pressure; CAD, coronary artery disease; COPD, chronic obstructive pulmonary disease; COVID-19, coronavirus disease 2019; ICU, intensive care unit; SNF, skilled nursing facility; SOFA, Sequential Organ Failure Assessment.

TABLE 2. In-hospital Mortality of Patients With COVID-19 Who Presented to Emergency Department/Hospital Assessed With Multivariable Logistic Regression (Odds Ratio) and Generalized Logistic Regression (Marginal Effects)

Demographic, Clinical and Health System Characteristics	All-cause In-hospital Mortality			
	Total Sample (n = 7556)		Age ≥ 65 Years (n = 3433)	
	Odds Ratio (95% CI)	Marginal Effect	Odds Ratio (95% CI)	Marginal Effect
Age (y)				
< 55	1 (reference)		—	—
55–64	3.28*** (2.41–4.46)	0.07***	—	—
65–74	4.67*** (3.43–6.35)	0.10***	1 (reference)	
75–84	10.73*** (7.77–14.81)	0.18***	2.39*** (1.87–3.05)	0.10***
85+	20.57*** (14.46–29.25)	0.27***	4.54*** (3.43–6.00)	0.19***
Female	0.83* (0.70–0.98)	−0.01*	0.78* (0.64–0.96)	−0.03*
Race/ethnicity				
White	1 (reference)		1 (reference)	
Black	0.96 (0.76–1.22)	−0.00	0.90 (0.68–1.19)	−0.01
Latinx	1.08 (0.84–1.39)	0.01	1.11 (0.83–1.49)	0.01
Other	1.16 (0.91–1.48)	0.01	1.35* (1.01–1.81)	0.04*
Medicaid	1.29 (1.00–1.68)	0.02	1.37 (0.91–2.06)	0.04
Elixhauser Comorbidity Index	1.11*** (1.16–2.13)	0.01***	1.06* (1.01–1.12)	0.01*
Serious illnesses				
Cancer	4.32*** (2.72–6.85)	0.11***	2.24** (1.25–4.01)	0.09**
COPD	3.63*** (2.95–4.47)	0.10***	3.83*** (2.98–4.92)	0.16***
Dementia	1.53*** (1.20–1.94)	0.03***	1.53** (1.19–1.97)	0.05**
CAD	1.35** (1.13–1.62)	0.02**	1.35** (1.09–1.67)	0.04**
Mortality (worst SOFA)				
< 10%	1 (reference)		1 (reference)	
15%–50%	4.10*** (3.08–5.47)	0.14***	5.44*** (3.77–7.87)	0.24***
> 50%	36.05*** (21.86–59.44)	0.44***	30.41*** (15.06–61.44)	0.49***
Discharge month				
March	1 (reference)		1 (reference)	
April	0.42*** (0.32–0.56)	0.07***	0.35*** (0.24–0.49)	−0.13***
May	0.11*** (0.08–0.17)	0.16***	0.09*** (0.05–0.15)	−0.27***
June	0.05*** (0.03–0.09)	0.20***	0.02*** (0.01–0.05)	−0.37***
Crowding	0.99 (0.98–1.01)	−0.00	0.99 (0.97–1.01)	−0.00
SNF resident before admission	1.57** (1.16–2.13)	0.04**	1.63** (1.17–2.27)	0.06**
Treatments received				
Dexamethasone	0.68 (0.43–1.09)	−0.03	0.53* (0.29–0.98)	−0.07*
ICU	0.82 (0.60–1.11)	−0.02	0.84 (0.56–1.26)	−0.02
Oxygen support received				
None	1 (reference)		1 (reference)	
Nasal cannula	0.59*** (0.47–0.74)	0.04***	0.61*** (0.48–0.79)	−0.06***
HFNC	4.19*** (2.91–6.05)	0.15***	4.82*** (3.14–7.40)	0.24***
BiPAP	9.31*** (6.93–12.50)	0.26***	9.95*** (6.93–14.28)	0.36***
Ventilator	8.87*** (6.49–12.13)	0.25***	9.58*** (6.38–14.39)	0.35***
Hospital site				
Mount Sinai (A)	1 (reference)		1 (reference)	
Mount Sinai (B)	1.99*** (1.49–2.66)	0.06***	2.34*** (1.63–3.36)	0.10***
Mount Sinai (C)	2.44*** (1.89–3.13)	0.07***	2.60*** (1.89–3.57)	0.12***
Mount Sinai (D)	0.52*** (0.39–0.71)	0.04***	0.66* (0.45–0.95)	−0.04*
Mount Sinai (E)	0.46*** (0.32–0.67)	0.05***	0.54* (0.35–0.83)	−0.06**

Crowding is measured by percent of households with > 1 occupants per room.

BiPAP indicates bilevel positive airway pressure; CAD, coronary artery disease; CI, confidence interval; COPD, chronic obstructive pulmonary disease; COVID-19, coronavirus disease 2019; HFNC, high-flow nasal cannula; ICU, intensive care unit; SNF, skilled nursing facility; SOFA, Sequential Organ Failure Assessment.

*P < 0.05.
**P < 0.01.
***P < 0.001.

0.08–0.17); June (OR, 0.05; 95% CI, 0.03–0.09)]. Older adults who received dexamethasone had a lower probability of mortality than those who did not receive dexamethasone (OR, 0.53; 95% CI, 0.29–0.98). There were no significant associations between sex, race/ethnicity, Medicaid insurance, and crowding, and all-cause mortality in either group.

Health System Characteristics and Mortality

There were differences in odds of mortality based on site where care was received. As compared with the quaternary care hospital (MSA), patient admitted to the 2 smaller community hospitals had a higher mortality probability [MSB (OR, 1.99, 95% CI, 1.49–2.66); MSC (OR, 2.44, 95% CI,
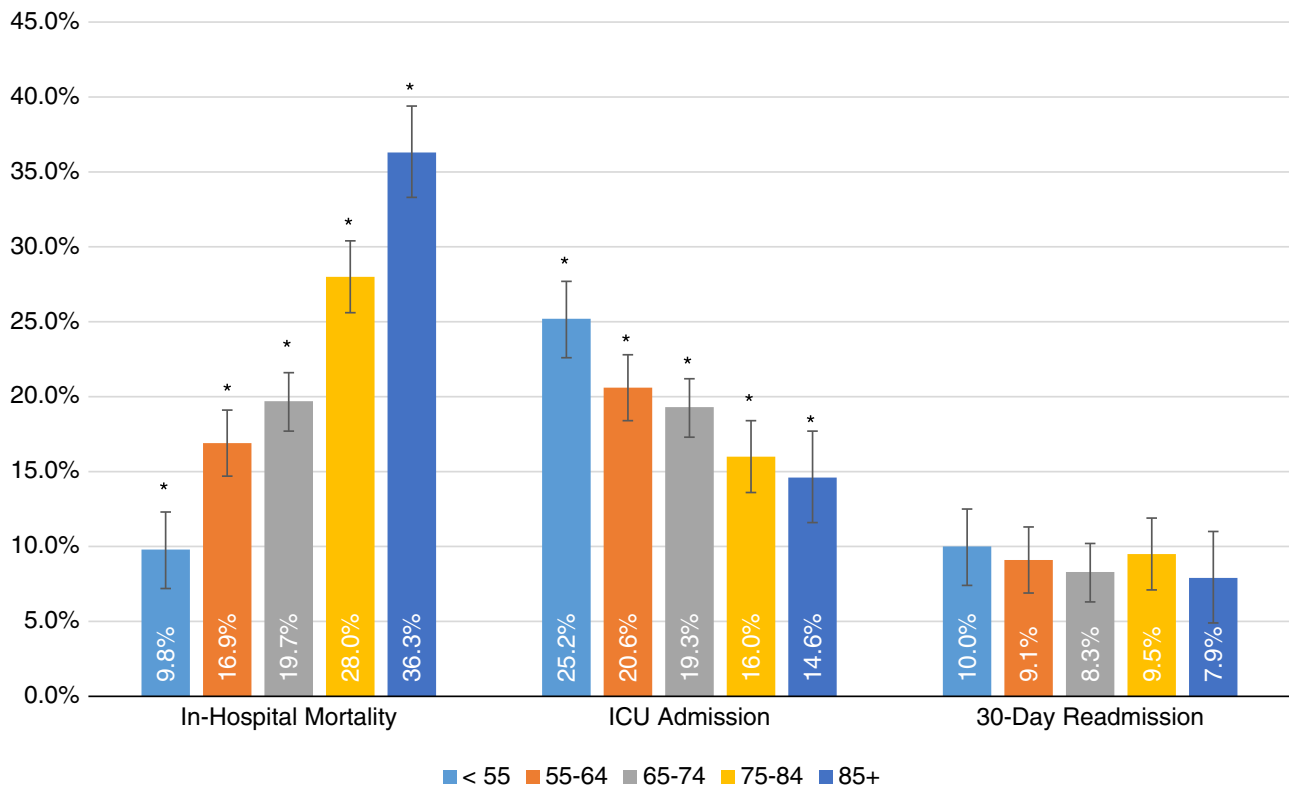
FIGURE 2. Predicted percentage of patients with each outcome by age. Using generalized linear regression models, we estimated the predicted percentage of patients with each outcome [in-hospital mortality, intensive care unit (ICU) admission, and 30-d readmission]. *$P < 0.05$. full color online

1.89–3.13)] and those admitted to the 2 mid-size hospitals had a lower mortality probability [MSD (OR, 0.52; 95% CI 0.39–0.71); MSE (OR, 0.46; 95% CI, 0.32–0.67)]. There were no associations between increasing census quartiles in overall hospital beds, ICU, or ED and all-cause mortality.

Viral Load and Mortality in Patients Presenting to the Emergency Department or Hospital With Coronavirus Disease 2019

Among those with viral load data (n = 4275), increased viral load was associated with mortality (OR, 1.04; 95% CI, 1.03–1.06). This model run with and without the viral load data as a predictor did not change the other predictors in a clinically meaningful way (Supplemental Table 1, Supplemental Digital Content 1, http://links.lww.com/MLR/C409).

Secondary Outcomes: Intensive Care Unit Admission and 30-Day Readmission

Older adults were significantly less likely to receive ICU care. Compared with those aged below 55 years, older adults were significantly less likely to be admitted to an ICU controlling for other factors (aged 55–64 y: OR, 0.56; 95% CI, 0.40–0.77; aged 65–74: OR, 0.46; 95% CI, 0.33–0.65; aged 75–84: OR, 0.27; 95% CI, 0.18–0.40; aged above 85 y: OR, 0.21; 95% CI, 0.13–0.34). The odd of being admitted to the ICU were half for those admitted from a SNF (OR, 0.53; 95% CI, 0.34–0.84). Comorbidities were independent risk factors for

ICU admission (OR, 1.13; 95% CI, 1.07–1.19) and 30-day readmission (OR, 1.18; 95% CI, 1.11–1.25). Having Medicaid insurance was associated with a lower probability of ICU admission (OR, 0.74; 95% CI, 0.56–0.99). Higher predicted mortality, using SOFA scores, was associated with a higher probability of ICU admission [mortality 15%–50% (OR, 7.44; 95% CI, 5.56–9.95); mortality > 50% (OR, 26.15; 95% CI, 16.85–40.59)]. Independent of comorbidities, having a cancer diagnosis was associated with a lower probability of ICU admission (OR, 0.53; 95% CI, 0.29–0.97), and having a diagnosis of cancer or CAD was associated with a higher probability of readmission [cancer (OR, 3.04; 95% CI, 1.72–5.36); CAD (OR, 1.43; 95% CI, 1.08–1.90)]. There were no associations between increasing census quartiles in the hospital, ICU, or ED and ICU admission or 30-day readmission (Table 3).

Model-predicted probability of ICU admission show difference in the predicted percentage of patients being admitted to the ICU varied from 25.2% for those aged below 55 years to 14.6% for those aged above 85 years (Fig. 2). There was no statistically significant difference in the predicted percentage of patients with 30-day readmission by age group within our health system (Fig. 2).

DISCUSSION

Our findings provide new insights into COVID-19 mortality risks and confirm prior studies' findings. The likelihood of in-

TABLE 3. ICU and Readmission Outcomes for Patients With COVID-19 Who Presented to Emergency Department/Hospital Assessed With Multivariable Logistic Regression (Odds Ratio) and Generalized Logistic Regression Model (Marginal Effects)

Demographic, Clinical and Health System Characteristics	ICU Admission Overall (n = 5154)		30-Day Readmission Overall (n = 3223)	
	Odds Ratio (95% CI)	Marginal Effect	Odds Ratio (95% CI)	Marginal Effect
Age (y)				
< 55	1 (reference)		1 (reference)	
55–64	0.56*** (0.40–0.77)	−0.05***	0.90 (0.61–1.32)	−0.01
65–74	0.46*** (0.33–0.65)	−0.06***	0.80 (0.53–1.22)	−0.02
75–84	0.27*** (0.18–0.40)	−0.09***	0.95 (0.61–1.49)	−0.00
85+	0.21*** (0.13–0.34)	−0.11***	0.77 (0.45–1.32)	−0.02
Female	0.88 (0.70–1.10)	−0.01	0.89 (0.69–1.16)	−0.01
Race/ethnicity				
White	1 (reference)		1 (reference)	
Black	0.94 (0.68–1.31)	−0.00	0.94 (0.66–1.35)	−0.00
Hispanic	1.15 (0.82–1.60)	0.01	0.92 (0.64–1.34)	−0.01
Other	1.20 (0.86–1.68)	0.01	0.62* (0.41–0.96)	−0.03*
Medicaid	0.74* (0.56–0.99)	−0.02*	1.15 (0.83–1.61)	0.01
Elixhauser Comorbidity Index	1.13*** (1.07–1.19)	0.01***	1.18*** (1.11–1.25)	0.01***
Serious illnesses				
Cancer	0.53* (0.29–0.97)	−0.04*	3.04*** (1.72–5.36)	0.13***
COPD	0.90 (0.67–1.19)	−0.01	1.06 (0.80–1.41)	0.00
Dementia	0.69 (0.46–1.05)	−0.02	1.06 (0.69–1.61)	0.00
Coronary artery disease	0.97 (0.76–1.24)	−0.00	1.43* (1.08–1.90)	0.03*
Mortality (worst SOFA)				
< 10%	1 (reference)		1 (reference)	
15%–50%	7.44*** (5.56–9.95)	0.21***	1.59 (0.94–2.70)	0.04
> 50%	26.15*** (16.85–40.59)	0.41***	2.28 (0.74–7.03)	0.08
Discharge month				
March	1 (reference)		1 (reference)	
April	0.64* (0.45–0.93)	−0.03*	0.84 (0.50–1.43)	−0.01
May	1.25 (0.79–1.97)	0.02	0.98 (0.53–1.82)	−0.00
June	2.07** (1.21–3.55)	0.06*	1.20 (0.61–2.37)	0.02
Crowding	0.98 (0.96–1.00)	−0.00	0.98 (0.96–1.01)	−0.00
SNF resident before admission	0.53** (0.34–0.84)	−0.04**	1.36 (0.86–2.16)	0.03
Treatments received				
Dexamethasone	2.25** (1.35–3.75)	0.06**	1.77 (0.95–3.30)	0.05
Maximal oxygen support				
None	1 (reference)		1 (reference)	
Nasal cannula	0.97 (0.69–1.35)	−0.00	1.02 (0.76–1.36)	0.00
HFNC	4.86*** (3.13–7.53)	0.14***	0.14*** (0.09–0.19)	−0.03
BiPAP	4.83*** (3.29–7.08)	0.14***	1.00 (0.57–1.74)	−0.00
Ventilator	26.83*** (18.56–38.78)	0.41***	0.56 (0.27–1.15)	−0.04
Hospital site				
Mount Sinai (A)	1 (reference)		1 (reference)	
Mount Sinai (B)	0.69 (0.46–1.02)	−0.02	1.07 (0.69–1.68)	0.01
Mount Sinai (C)	0.39*** (0.27–0.56)	−0.05***	1.27 (0.83–1.94)	0.02
Mount Sinai (D)	1.79*** (1.28–2.51)	0.04***	0.85 (0.57–1.26)	−0.01
Mount Sinai (E)	2.29*** (1.58–3.31)	0.06***	0.87 (0.56–1.36)	−0.01

Crowding is measured as the mean (median) number of households within the census tract who met crowding definition (ie, percentage of households with > 1 occupant per room).

BiPAP indicates bilevel positive airway pressure; CAD, coronary artery disease; CI, confidence interval; COPD, chronic obstructive pulmonary disease; COVID-19, coronavirus disease 2019; ICU, intensive care unit; SNF, skilled nursing facility; SOFA, Sequential Organ Failure Assessment.

*$P < 0.05$.
**$P < 0.01$.
***$P < 0.001$.

hospital mortality increased significantly as age increased independent of the sociodemographic, clinical, health system, and population characteristics. As compared with those below 55 years of age, the odds of dying in the hospital was > 3 times greater for those aged 55–64 and 20 times greater for those over the age of 85. We also found that admissions that occurred later in the calendar year were associated with a lower risk of mortality. We

hypothesize that this is due to enhanced understanding of effective treatments, such as proning,[27] medications (eg, remdesivir,[28] dexamethasone[25]), and health system efforts to balance the clinical load with individual hospital capacity.[29]

Furthermore, among older adults, receipt of dexamethasone was associated with a lower risk of mortality. In an unexpected finding, we demonstrated that older adults who

received dexamethasone had a lower risk of mortality. There was no association of dexamethasone and mortality in the overall sample. This finding is consistent with the existing data that dexamethasone could be an effective treatment for patients hospitalized with COVID-19 yet requires further investigation about the differential benefit to older adults. Perhaps the relatively dampened immune system of older adults' benefits from the additional inflammation suppression by dexamethasone, whereas the relative effect of the dexamethasone in younger adults is insufficient to overall the inflammatory effects of COVID-19 in hospitalized patients.

Consistent with prior studies, patients who presented with a higher viral load on admission was associated with higher mortality.[3,15] Increased comorbidity burden and serious illness were also associated with in-hospital mortality.[30–32] Independent of age, comorbidities, serious illness, and illness severity, those admitted from a SNF were 1.6 times more likely to die than those presenting from home. Despite the disproportionate number of COVID-19-related deaths, we found no differences in mortality rates, ICU admission, nor 30-day readmission among hospitalized Black and Latinx patients with COVID-19 compared with White patients when controlling for other variables.[33,34] Recent studies have demonstrated that although African American/Black and Latinx populations experience disproportionately higher rates of SARS-CoV-2 infection and COVID-19-related mortality, they experience similar rates of mortality among those with confirmed COVID-19.[35] We hypothesize that this can be attributed to differences in health care access, including testing and risk of exposure.

In contrast to in-hospital mortality, the likelihood of being admitted to the ICU decreased as age increased. Specifically, as compared with those aged below 55 years, those aged 55–64 were half as likely to be admitted to the ICU and those 85 years and older were a quarter as likely to be admitted the ICU after controlling for factors including illness severity, comorbidities, and serious illness. This finding requires further investigation to understand how age and treatment preference factored into resource allocation and critical supply shortages. Other work has demonstrated dementia, a serious illness of older adults was associated with lower treatment intensity and higher mortality among patients hospitalized with COVID-19. Similar to our work, this association was attributed to a possible interplay between provider bias and treatment preference.[36–41] Furthermore, after controlling for age, patients admitted from a SNF were also half as likely to be admitted to an ICU. Whereas these findings may be explained by the patient and/or family preferences, we cannot exclude the possibility that clinicians may have made informal triage decisions regarding scarce ICU beds based largely on patients' age.[38,42]

Our study also examined how other factors (ie, Medicaid, population density, and household crowding) capturing socioeconomic disparities might account for the disproportionate number of COVID-19-related deaths among Black and Hispanic populations.[43] Although we found having Medicaid was associated with a lower likelihood of being admitted to the ICU, we found no associations between population density and household crowding with mortality, ICU admission, nor 30-day readmission. Medicaid insurance served as a proxy for socioeconomic status. Yet, population density and household

crowding may not have captured other social determinants, including structural inequities such as access to health care, which may drive this disproportionate impact. Furthermore, our use of census tract is an imprecise method of capturing population density. We also included viral load data to help understand the impact of public health prevention measures such as mask-wearing and physical distancing. Though these data would not be available to clinicians when caring for patients in the ED/hospital, viral load data may reflect the amount of exposure to SARS-CoV-2 and was associated with mortality.

Finally, we identified differences in odds of mortality based on the hospital site where care was received. Specifically, there were increased odds of mortality for those who received care at the 2 smaller community hospitals and decreased odds of mortality at the mid-sized tertiary community hospitals when compared with the large, quaternary academic medical center. This finding is likely due to many factors, though the most likely explanation stems from hospital location. The 2 community hospitals are situated within neighborhoods that experienced the largest numbers of COVID-19 cases during the first months of the pandemic. Whereas the health system developed a "load balancing"[44] system whereby patients were transferred between hospitals, many who presented to the smaller hospitals were too unstable for transfer. That is, the healthiest and most stable patients were transferred from the community hospitals to the mid-sized tertiary hospitals, sicker patients were transferred to the quaternary academic medical center, and those most seriously ill or desiring comfort-focused care were not transferred. Due to limitations of the health system and billing data, we were unable to measure other factors that might have accounted for these differences, such as hospital capacity (ie, staffing, hospital bed availability, ICU beds, and ventilators) and neighborhood differences (ie, SARS-CoV-2 testing capacity, unmeasured chronic illness, structural barriers to health care access, local rapid increases in demand, and hospital and ICU bed availability).

Limitations

This study has limitations. Our study population included only patients who received care at an urban health system and therefore may not be generalizable. Second, we established our sample using EHR and billing data; this may have resulted in an incomplete sample. Third, our study aimed to identify factors associated with mortality from COVID-19, and the estimates of associations may not reflect causal effects. Furthermore, the race/ethnicity entered in the EHR are not exclusively patient-reported. Fourth, the mortality that occurred during the pandemic's first wave in NYC may not reflect subsequent waves. Finally, the limited availability of testing and the avoidance of patients going to the hospital in this may underestimate the actual mortality rates.

CONCLUSIONS

In this study of patients who presented to the ED with COVID-19, the all-cause mortality rate was 21%, ICU admission rate was 13%, and among those discharged alive, the 30-day readmission rate was 5%. Those who were older, had

more comorbidities, a serious illness, higher disease severity, and admitted from an SNF were at increased mortality risk. Older adults, those with multiple comorbidities or cancer, Medicaid, or admitted from an SNF were less likely to be admitted to the ICU. Factors associated with increased readmission included multiple comorbidities and a diagnosis of cancer or heart disease. These findings can be important to improve medical decision-making for clinicians, patients, and their families and address potential bias when considering the use of critical care among older adults.

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