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MAJOR ARTICLE

Correlates of Coronavirus Disease 2019 Inpatient Mortality at a Southern California Community Hospital With a Predominantly Hispanic/Latino Adult Population

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Background. Studies of inpatient coronavirus disease 2019 (COVID-19) mortality risk factors have mainly used data from academic medical centers or large multihospital databases and have not examined populations with large proportions of Hispanic/Latino patients. In a retrospective cohort study of 4881 consecutive adult COVID-19 hospitalizations at a single community hospital in Los Angeles County with a majority Hispanic/Latino population, we evaluated factors associated with mortality.

Methods. Data on demographic characteristics, comorbidities, laboratory and clinical results, and COVID-19 therapeutics were abstracted from the electronic medical record. Cox proportional hazards regression modeled statistically significant, independently associated predictors of hospital mortality.

Results. Age ≥65 years (hazard ratio [HR] = 2.66; 95% confidence interval [CI] = 1.90–3.72), male sex (HR = 1.31; 95% CI = 1.07–1.60), renal disease (HR = 1.52; 95% CI = 1.18–1.95), cardiovascular disease (HR = 1.45; 95% CI = 1.18–1.78), neurological disease (HR = 1.84; 95% CI = 1.41–2.39), D-dimer ≥500 ng/mL (HR = 2.07; 95% CI = 1.43–3.0), and pulse oxygen level <88% (HR = 1.39; 95% CI = 1.13–1.71) were independently associated with increased mortality. Patient household with (1) multiple COVID-19 cases and (2) Asian, Black, or Hispanic compared with White non-Hispanic race/ethnicity were associated with reduced mortality. In hypoxic COVID-19 inpatients, remdesivir, tocilizumab, and convalescent plasma were associated with reduced mortality, and corticosteroid use was associated with increased mortality.

Conclusions. We corroborate several previously identified mortality risk factors and find evidence that the combination of factors associated with mortality differ between populations.

Keywords. community hospital; COVID-19; Hispanic; Latino; mortality.

Seeking to identify a common set of predictors of coronavirus disease 2019 (COVID-19) mortality in the initial 18 months of the pandemic, large studies from China [1, 2], United States [3–5], Italy [6], United Kingdom (UK) [7], and Canada [8] and multiple meta-analyses [9–21] have consistently found increasing age, male sex, medical comorbidities, and/or laboratory abnormalities as risk factors, yet with noted heterogeneity between different reports [10, 11, 14, 16, 19]. Patient populations for these studies have been dominated by academic medical center cohorts or large multihospital databases [1–8], and, consequently, findings may not apply directly to patient populations of individual community hospitals. Furthermore, only 4 meta-analyses included populations with at least 12% Hispanic/Latino ethnicity [3, 14, 21, 22], and outcomes of therapeutic interventions are rarely described [18]. Los Angeles County (LAC), with a 49.1% Hispanic/Latino population [23], has experienced the highest number of COVID-19 cases and deaths of all US counties, with over 3.4 million cases and over 33 000 deaths through August 2022 [24].

In this single-center retrospective cohort study, our objectives were 2-fold. First, we sought to identify factors that independently predicted COVID-19 hospital mortality during the first 14 months of the COVID-19 pandemic at a single Southern California community hospital with a majority Hispanic/Latino adult patient population. Second, we examined the effects of available COVID-19 therapeutics on mortality.

METHODS

Study Population

Patients were hospitalized with COVID-19 at Pomona Valley Hospital Medical Center (PVHMC) between March 9, 2020

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and April 30, 2021, a period corresponding with 2 initial COVID-19 surges in LAC [25]. The PVHMC is an accredited 412-bed, not-for-profit, independent, acute care community hospital providing a range of healthcare services in eastern LAC and western San Bernardino County. In 2020–2021, 52.8% of all inpatients were Hispanic/Latino; in 2021, at least 39% of patients were low income as indicated by California's Medicaid health insurance coverage (Medi-Cal). Internal PVHMC data showed no significant change in the racial and ethnic composition of the hospital's inpatient population from 2019 to 2021.

From a list of all patients with laboratory-confirmed severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) infection provided, as required, to LAC Department of Public Health, 5287 admissions during the study period were identified. We excluded (1) 7 patients for whom COVID-19 could not be substantiated and (2) 399 patients younger than 20 years because PVHMC does not provide pediatric critical care services (only 13 cases with no deaths occurred in the 18- and 19-year-olds with COVID-19 during the study period). The remaining 4881 adult inpatients at least 20 years of age with COVID-19 comprised the study population (Figure 1).

Data Sources and Variables

Patient demographics, comorbid disease diagnoses (Supplementary Table 1), medical history from physician assessments, laboratory results, and clinical characteristics data were abstracted from the patient electronic medical record (EMR), relevant transfer records, and automated reports extracted from the EMR by clinical team members with EMR authorization.

We focused on factors identified by previous studies [1–4, 6, 11, 17, 20, 26–33] or that we hypothesized would be associated with mortality in our patient population, prioritizing parameters obtained during a typical hospital intake because these are reliably documented and readily abstracted. Demographic characteristics were collected from patients by hospital staff, including age, sex, race, Hispanic/Latino ethnicity, primary language spoken, and whether more than 1 household member had been diagnosed with COVID-19 at the time of admission. Attempts to retrieve missing data were made. A variable that combined race and ethnicity was created. Patients were classified as follows: Asian, Native Hawaiian or Pacific Islander Non-Hispanic/Latino; Black or African American Non-Hispanic/Latino; Hispanic/Latino; Other Non-Hispanic/Latino (included American Indian or Alaska Native) or White Non-Hispanic/Latino.

We calculated body mass index (BMI) using self-reported height and measured weight, or, secondarily, recent hospital records or patient-provided identification on file. Possible outlier values were investigated on a case-by-case basis; implausible values were set to missing. To estimate overall comorbidity risk, we summed comorbid conditions including cardiovascular disease (CVD), chronic liver disease, chronic pulmonary disease, chronic renal disease, active malignancy, obesity, diabetes, and hypertension.

Laboratory data were available for glucose, D-dimer, C-reactive protein (CRP), red cell distribution width (RDW), neutrophils, A1C, measured pulse oxygen saturation, and ratio of arterial oxygen partial pressure (mmHg) to fractional inspired oxygen (P/F ratio). For multiple measurements, we prioritized the initial result from the COVID-19 admission. Previous admission was defined as hospital admission within the past 30 days; admission from a skilled nursing facility was noted.

Decisions determining patient admission, diagnostic testing, and therapeutic interventions were made by clinicians based on patient status assessments. Based upon contemporary published data, professional society guidelines, and laboratory and therapeutics availability, hospital COVID-19 clinical care recommendations were frequently updated and disseminated via in-person and virtual meetings and intranet resources.

Outcomes

Hospital mortality was defined as patient death occurring during the COVID-19 hospital admission. Length of stay (LOS) in the hospital was counted as the number of days from admission to discharge.

Patient Consent Statement

Informed consent was waived because the study was considered retrospective and based on deidentified abstracted EMR data.

Statistical Analysis

Descriptive statistics for patients were summarized overall and compared between groups based on patient intensive care unit (ICU) admission and discharge status using χ^2 and t tests or analysis of variance. Statistical tests were 2-sided with statistical significance set at $\alpha = 0.05$. Follow-up time began at the date of hospital admission and ended at the date of discharge, death, or end of follow up, on June 17, 2021. We plotted survival curves using the Kaplan-Meier method, and differences in survival between groups were tested with the log-rank test. Patients who had not yet been discharged were censored at the end of follow up. To identify correlates of mortality, we used Cox proportional hazards regression, beginning with demographic, laboratory, and comorbidity characteristics (Table 1) in a preliminary model. We then sequentially removed variables not associated with inpatient mortality using a $P = .10$ threshold and derived a multivariable model that included statistically significant (at $P = .05$), independently associated predictors. Lower values of −2 log likelihood, Akaike's information criteria, and Schwarz Bayesian criterion in models with covariates compared to those without were indicative of better fit. To replace missing data, we used multiple imputation techniques using fully conditional

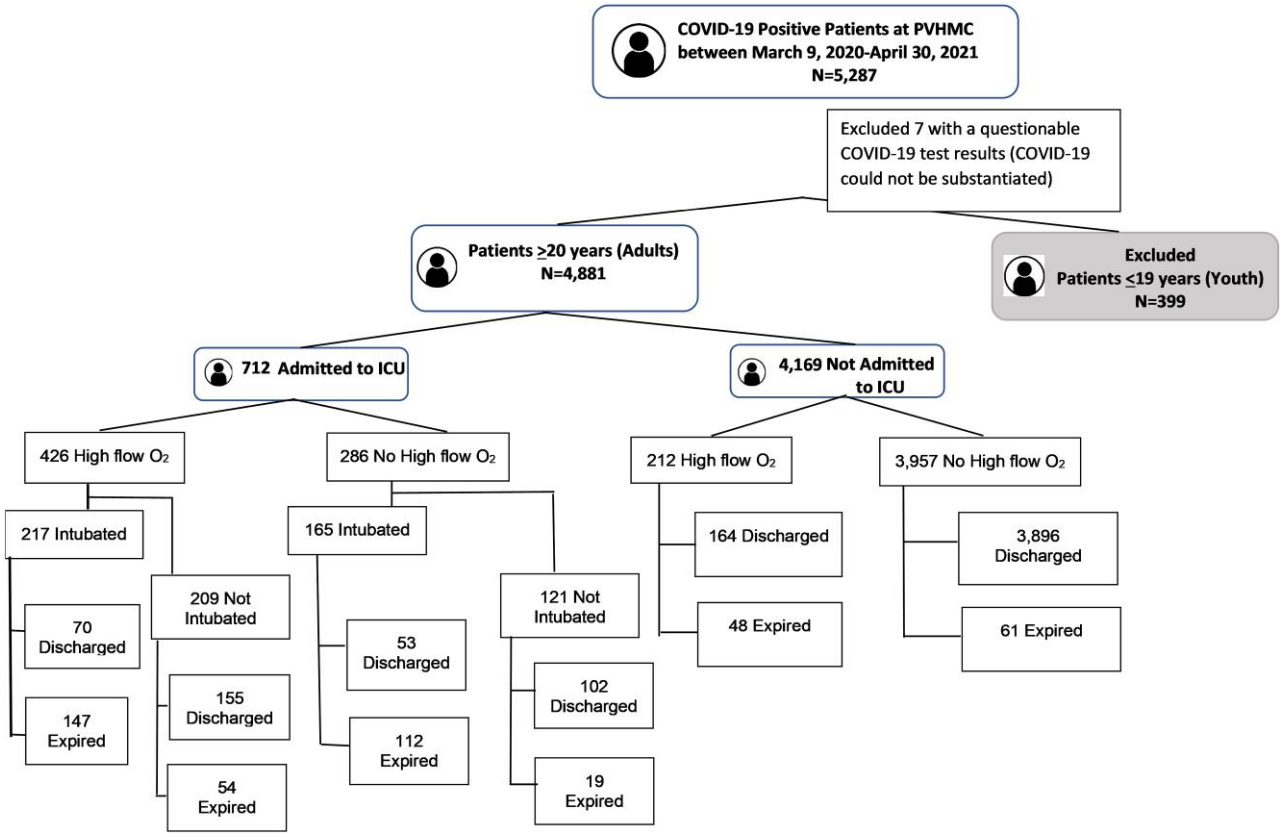

Figure 1. Patient flow diagram. COVID-19, coronavirus disease 2019; ICU, intensive care unit.

specification with a discriminant function for categorical variables and linear regression for continuous variables. Twenty imputation datasets were used. Continuous variables in final multivariable models were scaled to clinically interpretable categories (Table 1); interaction terms for age and D-dimer with time were included to fulfill the proportionality assumption. Hazard ratios (HRs) and 95% confidence intervals (CIs) were estimated from models and expressed the increased or decreased hospital mortality risk associated with a given characteristic compared to a reference group of the characteristic.

To examine therapeutic effects, we compared patients who had received each individual therapy to those who had not in regression models adjusted for covariates identified as correlates of inpatient mortality. We conducted sensitivity analyses as follows: due to changes in eligibility criteria for therapeutics over time, we estimated treatment effects in models restricted to hypoxic patients (P/F ratio ≤ 300 or pulse oxygen $< 88\%$; n = 1398). To minimize the influence of prior medical care, we excluded patients (n = 709) who had a previous hospital admission. Because many patients had received more than 1 available therapeutic, we estimated treatment HRs from models adjusted for all other therapies.

All analyses used SAS version 9.4 (SAS Institute Inc., Cary, NC). The study was approved by the PVHMC Institutional Review Board (protocol number 2020-1028).

RESULTS

A total of 4881 adult patients at least 20 years of age with COVID-19 were admitted between March 9, 2020 and April 30, 2021, with peaks between June and August 2020 and November 2020 and January 2021 (Supplementary Figure 1). Mean age was 52.6 (standard deviation [SD] = 18.7) years; 51.4% were women, 65.8% were Hispanic/Latino, and 30% had more than 1 household member diagnosed with COVID-19 (Table 1). Mean BMI was 30.1 (SD = 6.3); one third had diabetes mellitus, 43.2% had hypertension, and 28.8% had CVD. A total of 9.6% presented with a pulse oxygen rate <88%. Average LOS was 5.1 (SD = 7.3) days; 13.1% received high-flow oxygen, 7.9% were intubated, 14.6% were admitted to the ICU, and 9% died (Figure 1, Supplementary Table 2).

Patients who died in the hospital were older, more likely male, Asian, Pacific Islander, or Native Hawaiian, White, and Spanish speaking and less likely from a multiple COVID-19 case household or obese. Patients who died were more likely

to have diabetes mellitus, hypertension, chronic liver disease, chronic pulmonary disease, chronic renal disease, CVD, active malignancy, any neurological disease, and more comorbidities overall. Compared with those discharged alive, patients who died had higher mean levels of glucose, D-dimer, CRP, neutrophils, and RDW, but lower pulse oxygen levels. There was no difference in mean A1C, but there was a significantly higher percentage of uncontrolled or critically high A1C levels among patients who died compared to those who were discharged (Table 1). Kaplan-Meier analysis showed differences in survival among patients based on age ($P < .0001$), sex ($P = .0008$), and race/ethnicity ($P = .004$) (Supplementary Figure 2).

Factors independently associated with hospital mortality were age, sex, race/ethnicity, multiple member COVID-19 household status, renal disease, CVD, neurological disease, D-dimer, glucose, and pulse oxygen levels. Patients who were ≥65 years were 2.66 times as likely to die (95% CI = 1.90–3.72), and men were 31% more likely (HR = 1.31; 95% CI = 1.07–1.60) to die than women (Table 2). Considered as a group, patients who were Asian, Black, or Hispanic/Latino were less likely to die than White patients (HR = 0.79; 95% CI = .62–.99), and a multimember COVID-19 household was associated with a lower mortality (HR = 0.76; 95% CI = .61–.96). Mortality was ~50% greater in patients with renal disease (HR = 1.52; 95% CI = 1.18–1.95) or CVD (HR = 1.45; 95% CI = 1.18–1.78) and more frequent among those with neurological disease (HR = 1.84; 95% CI = 1.41–2.39). The hazard ratio for D-dimer ≥500 ng/mL was 2.07 (95% CI = 1.43–3.0) and 1.11 for glucose >180 mg/dL (95% CI = .91–1.35). Patients with pulse oxygen <88% at admission had 39% greater risk of mortality (95% CI = 1.13–1.71). It is notable that diabetes mellitus, BMI, and Hispanic/Latino race/ethnicity were not associated with increased mortality.

Seven COVID-19 therapeutics were prescribed at some time during the study period (Figure 2). After adjusting for mortality risk factors and other therapeutics, remdesivir (HR = 0.49; 95% CI = .36–.67) and tocilizumab (HR = 0.73; 95% CI = .54–1.00) were associated with lower mortality, and corticosteroids (HR = 2.29; 95% CI = 1.26–4.15) were associated with higher mortality (Table 3). The effect of remdesivir was most pronounced among hypoxic patients (HR = 0.44; 95% CI = .32–.61) (Table 3). Hypoxic patients treated with tocilizumab were one third less likely to die in the hospital (HR = 0.69; 95% CI = .50–.94), and they experienced a reduction in mortality with convalescent plasma treatment (HR = 0.72; 95% CI = .54–.96), whereas corticosteroids receipt was associated with higher mortality (HR = 2.39; 95% = 1.21–4.71) (Table 3).

DISCUSSION

In our study of 4881 predominantly Hispanic/Latino adult patients with COVID-19 at a single independent Southern California community hospital between March 9, 2020 and April 30, 2021, age ≥65 years, male sex, renal disease, CVD, neurologic disease, elevated D-dimer, increased glucose levels, and low pulse oxygen level were independently associated with increased mortality, whereas Asian, Black, or Hispanic/Latino race/ethnicity and coming from a multiple member COVID-19 household were associated with lower mortality. We found remdesivir, tocilizumab, and convalescent plasma independently associated with reduced risk of mortality among hypoxic patients, and corticosteroids use independently associated with increased mortality in both hypoxic and all patients.

Our findings generally agree with published studies and meta-analyses [1–21, 25–34] reporting increasing age, male sex, medical comorbidities, and multiple laboratory abnormalities as COVID-19 mortality risk factors. This concurrence supports the concept of a shared set of mortality risk factors among inpatients with COVID-19 irrespective of study population origin. However, our results add to the evidence [10–12, 16, 19] that the combination of factors, which together predict inpatient COVID-19 mortality, differ between populations and may vary based on the proportion of Hispanic/Latino patients with COVID-19 in the population [5].

Although 45% of our patients hospitalized with COVID-19 were obese compared with 28% of the LAC adult population [35], we did not find obesity independently associated with hospital mortality. Our results differ from several studies identifying obesity [5, 31, 36] or increased BMI [4, 11, 14, 16, 31, 37–45] as risk factors for COVID-19 mortality, but they agree with others [3]. Attempts to pool effects in meta-analyses have led to conclusions that despite obesity being a common comorbidity among patients with COVID-19 , it is not a strong mortality predictor [16, 46]. One meta-analysis that included 17 studies with data on obesity and BMI from over 20 000 patients hospitalized [16] found associations with in-hospital mortality were dependent on study population makeup. Increased mortality from obesity was noted only in studies with a predominance of patients who were male, younger (≤60 years old), or not in poor health. Pooled results suggested patient age is a significant source of heterogeneity for BMI, and increased BMI is a prognostic factor in patients with fewer comorbidities. It is possible in our patient population, the importance of obesity and elevated BMI as independent risk factors for COVID-19 mortality was outweighed by other comorbidities. Our research indicated that once demographic characteristics, comorbidities, and laboratory and clinical parameters were accounted for, BMI did not add predictive value to models of inpatient mortality.

Before attempts to resolve missing values, we observed that patients without BMI data were generally younger, more likely to be Hispanic/Latino, and had lower glucose, CRP, and D-dimer levels, higher pulse oxygen levels, and fewer comorbidities, perhaps reflective of a "healthier" COVID-19 risk profile. We filled in missing BMI values using state-issued

Table 1. Characteristics of Adult Patients (n = 4881) Aged 20 Years and Older Admitted to PVHMC With Coronavirus Disease During March 9, 2020 and April 30, 2021, by Admission to ICU and Discharge Status

Characteristic, No. (%) or Mean ± SD	Overall N = 4881	Not Admitted to ICU n = 4169	Admitted to ICU n = 712	*P* Value	Discharged Alive n = 4440	Died n = 441	*P* Value
Demographic Factors	…	…	…		…	…	
Age	52.6 ± 18.7	50.9 ± 18.7	62.8 ± 14.8	<.0001	50.9 ± 18.2	70.3 ± 13.6	<.0001
Age, Years (Categories)	…	…	…	<.0001	…	…	<.0001
20–29	677 (13.9%)	654 (15.7%)	23 (3.2%)		677 (15.3%)	0 (0%)	
30–49	1485 (30.4%)	1385 (33.2%)	100 (14.0%)		1457 (32.8%)	28 (6.3%)	
50–64	1334 (27.3%)	1092 (26.2%)	242 (34.0%)		1212 (27.3%)	122 (27.7%)	
65–74	706 (14.5%)	529 (12.7%)	177 (24.9%)		601 (13.5%)	105 (23.8%)	
75+	679 (13.9%)	509 (12.2%)	170 (23.9%)		493 (11.1%)	186 (42.2%)	
Sex	…	…	…	<.0001	…	…	<.0001
Male	2374 (48.6%)	1906 (45.7%)	468 (65.7%)		2094 (47.2%)	280 (63.5%)	
Female	2507 (51.4%)	2263 (54.3%)	244 (34.3%)		2346 (52.8%)	161 (36.5%)	
Race/Ethnicity	…	…	…	.05	…	…	.0007
Asian, Native Hawaiian or Pacific Islander Non-Hispanic/Latino	352 (7.2%)	284 (6.8%)	68 (9.5%)		306 (6.9%)	46 (10.4%)	
Black or African American Non-Hispanic/Latino	266 (5.5%)	232 (5.6%)	34 (4.8%)		248 (5.6%)	18 (4.1%)	
Hispanic/Latino	3211 (65.8%)	2765 (66.3%)	446 (62.6%)		2953 (66.5%)	258 (58.5%)	
Other Non-Hispanic/Latino (includes American Indian or Alaska Native)	192 (3.9%)	160 (3.8%)	32 (4.5%)		172 (3.9%)	20 (4.5%)	
White Non-Hispanic/Latino	860 (17.6%)	728 (17.5%)	132 (18.5%)		761 (17.1%)	99 (22.5%)	
Primary Language	…	…	…	.003	…	…	.003
English	3604 (73.8%)	3113 (74.7%)	491 (69.0%)		3312 (74.6%)	292 (66.2%)	
Spanish	1206 (24.7%)	1001 (24.0%)	205 (28.8%)		1072 (24.1%)	134 (30.4%)	
Other	71 (1.5%)	55 (1.3%)	16 (2.2%)		56 (1.3%)	15 (3.4%)	
Multimember COVID-19 Household	…	…	…	.002	…	…	<.0001
No	3371 (70.0%)	2839 (69.2%)	532 (74.8%)		3026 (69.1%)	345 (79.0%)	
Yes	1445 (30.0%)	1266 (30.8%)	179 (25.2%)		1353 (30.9%)	92 (21.0%)	
BMI	30.1 ± 6.3	30.0 ± 6.2	30.3 ± 6.5	.36	30.2 ± 6.2	29.1 ± 6.5	.0008
Underweight (BMI <18.5)	40 (0.9%)	33 (0.9%)	7 (1.0%)	.88	32 (0.8%)	8 (1.9%)	.0003
Normal weight (BMI 18.5–24.9)	941 (20.8%)	801 (20.9%)	140 (20.3%)		828 (20.2%)	113 (27.0%)	
Overweight (BMI 25–29.9)	1508 (33.3%)	1272 (33.1%)	238 (34.4%)		1370 (33.3%)	138 (32.9%)	
Obese (BMI of 30 or greater)	2039 (45.0%)	1733 (45.1%)	306 (44.3%)		1879 (45.7%)	160 (38.2%)	
BMI < 40	4188 (92.5%)	3562 (92.8%)	626 (90.6%)	.04	3797 (92.4%)	391 (93.3%)	.5
BMI ≥40	340 (7.5%)	275 (7.2%)	65 (9.4%)		312 (7.6%)	28 (6.7%)	
Comorbidities							
Number of comorbidities including obesity, hypertension, and diabetes	1.7 ± 1.4	1.6 ± 1.4	2.8 ± 1.3	<.0001	1.6 ± 1.4	2.9 ± 1.3	<.0001
Diabetes History	…	…	…	<.0001	…	…	<.0001
Nondiabetic	2480 (50.8%)	2378 (57.0%)	102 (14.3%)		2402 (54.1%)	78 (17.7%)	
Prediabetic	751 (15.4%)	571 (13.7%)	180 (25.3%)		644 (14.5%)	107 (24.3%)	…
Diabetic	1649 (33.8%)	1219 (29.3%)	430 (60.4%)		1393 (31.4%)	256 (58.1%)	…
Hypertension History	…	…	…	<.0001	…	…	<.0001
non-HTN	2771 (56.8%)	2577 (61.8%)	194 (27.3%)		2673 (60.2%)	98 (22.2%)	
HTN	2110 (43.2%)	1592 (38.2%)	518 (72.7%)		1767 (39.8%)	343 (77.8%)	
Hyperlipidemia history	…	…	…	.32	…	…	.84
No hyperlipidemia	4320 (88.5%)	3682 (88.3%)	638 (89.6%)		3931 (88.5%)	389 (88.2%)	
Hyperlipidemia	561 (11.5%)	487 (11.7%)	74 (10.4%)		509 (11.5%)	52 (11.8%)	
Any Chronic Liver Disease	…	…	…	.004	…	…	.007
No	4738 (97.1%)	4059 (97.4%)	679 (95.4%)		4319 (97.3%)	419 (95.0%)	
Yes	143 (2.9%)	110 (2.6%)	33 (4.6%)		121 (2.7%)	22 (5.0%)	
Any Chronic Pulmonary Disease	…	…	…	<.0001	…	…	<.0001
No	4225 (86.6%)	3659 (87.8%)	566 (79.5%)		3876 (87.3%)	349 (79.1%)	
Yes	655 (13.4%)	509 (12.2%)	146 (20.5%)		563 (12.7%)	92 (20.9%)	

Table 1. Continued

Characteristic, No. (%) or Mean ± SD	Overall N = 4881	Not Admitted to ICU n = 4169	Admitted to ICU n = 712	*P* Value	Discharged Alive n = 4440	Died n = 441	*P* Value
Any Chronic Renal Disease	…	…	…	<.0001	…	…	<.0001
No	4556 (93.3%)	3937 (94.4%)	619(86.9%)		4196 (94.5%)	360(86.9%)	
Yes	325 (6.7%)	232 (5.6%)	93 (13.1%)		244 (5.5%)	81 (13.1%)	
Any Cardiovascular Disease	…	…	…		…	…	
No	3477 (71.2%)	3169 (76.0%)	308 (43.3%)	<.0001	3320 (74.8%)	157 (35.6%)	<.0001
Yes	1404 (28.8%)	1000 (24.0%)	404 (56.7%)		1120 (25.2%)	284 (64.4%)	
Active Malignancy	…	…	…	.001	…	…	<.0001
No	4729 (96.9%)	4053 (97.2%)	676 (94.9%)		4319 (97.3%)	410 (93.0%)	
Yes	152 (3.1%)	116 (2.8%)	36 (5.1%)		121 (2.7%)	31 (7.0%)	
Any Severe Psychiatric History	…	…	…	.6	…	…	.02
No	4743 (92.7%)	4049 (97.1%)	694 (92.1%)		4322 (97.3%)	421 (95.5%)	
Yes	138 (7.3%)	120 (2.9%)	18 (7.9%)		118 (2.7%)	20 (4.5%)	
Any Neurological Disease/ Condition	…	…	…	.001	…	…	<.0001
No	4560 (93.4%)	3915 (93.9%)	645 (90.6%)		4197 (94.5%)	363 (82.3%)	
Yes	321 (6.6%)	254 (6.1%)	67 (9.4%)		243 (5.5%)	78 (17.7%)	
Any Immune or Autoimmune Disorder	…	…	…	.53	…	…	.88
No	4829 (98.9%)	4123 (98.9%)	706 (99.2%)		4393 (98.9%)	436 (98.9%)	
Yes	52 (1.1%)	46 (1.1%)	6 (.8%)		47 (1.1%)	5 (1.1%)	
Laboratory and Clinical Measures	…	…	…		…	…	
Glucose mg/dL	185.2 ± 114.9	167.2 ± 90.9	231.7 ± 151.6	<.0001	177.7 ± 106.5	222.1 ± 144.0	<.0001
D-dimer	1916.8 ± 6866.0	1310.6 ± 5140.0	3446.6 ± 9813.4	<.0001	1324.1 ± 5079.6	4801.1 ± 11 886.8	<.0001
Normal (<500 ng/mL)	1238 (61.5%)	966 (67.0%)	272 (47.6%)	<.0001	1118 (67.0%)	120 (45.0%)	<.0001
Abnormal (≥500 ng/mL)	774 (38.5%)	475 (33.0%)	299 (52.4%)		551 (33.0%)	223 (65.0%)	
CRP, mg/L	13.1 ± 9.9	11.8 ± 9.3	16.6 ± 10.6	<.0001	12.2 ± 9.4	17.6 ± 10.7	<.0001
<10	984 (45.6%)	800 (50.9%)	184 (31.4%)	<.0001	892 (49.2%)	92 (26.5%)	<.0001
10–19.9	695 (32.2%)	496 (31.5%)	199 (34.0%)		570 (31.5%)	125 (36.0%)	
≥20	479 (22.2%)	276 (17.6%)	203 (34.6%)		349 (19.3%)	130 (37.5%)	
Pulse Ox, %	94.4 ± 7.2	95.6 ± 5.0	87.7 ± 12.5	<.0001	95.2 ± 5.6	86.3 ± 13.9	<.0001
≥88%	4399 (90.4%)	3928 (94.6%)	471 (66.2%)	<.0001	4125 (93.1%)	274 (63.1%)	<.0001
<88%	466 (9.6%)	226 (5.4%)	240 (33.8%)		306 (6.9%)	160 (36.9%)	
RDW, %	14.5 ± 5.7	14.5 ± 6.4	14.8 ± 2.2	.23	14.4 ± 6.1	15.2 ± 2.5	.008
≤14.5%	2053 (66.9%)	1630 (69.1%)	423 (59.6%)	<.0001	1844 (69.9%)	209 (48.7%)	<.0001
>14.5%	1016 (33.1%)	729 (30.9%)	287 (40.4%)		796 (30.1%)	220 (51.3%)	
Neutrophils, $\times 10^9$/L	6.9 ± 4.6	6.3 ± 4.4	9.1 ± 4.7	<.0001	6.6 ± 4.5	9.0 ± 5.0	<.0001
≤8.2	2090 (71.6%)	1753 (77.6%)	337 (50.8%)	<.0001	1902 (74.5%)	188 (51.0%)	<.0001
>8.2	832 (28.4%)	506 (22.4%)	326 (49.2%)		651 (25.5%)	181 (49.0%)	
A1C, %	7.2 ± 2.2	7.0 ± 2.0	7.7 ± 2.5	<.0001	7.2 ± 2.2	7.3 ± 2.1	.29
<5.7: nondiabetic	414 (17.5%)	326 (19.5%)	88 (12.7%)	<.0001	354 (18.1%)	60 (14.8%)	.007
5.7–6.4: prediabetes	836 (35.4%)	633 (37.9%)	203 (29.4%)		713 (36.4%)	123 (30.3%)	
6.5–6.9: controlled diabetes	262 (11.1%)	175 (10.5%)	87 (12.6%)		207 (10.6%)	55 (13.5%)	
7.0–8.9: uncontrolled diabetes	449 (19.0%)	298 (17.8%)	151 (21.9%)		353 (18.1%)	96 (23.7%)	
≥9.0: critically high	401 (17.0%)	239 (14.3%)	162 (23.4%)		329 (16.8%)	72 (17.7%)	
Hypoxic (P/F ≤300)	…	…	…	<.0001	…	…	<.0001
No	125 (8.9%)	95 (12.4%)	30 (4.7%)		113 (11.0%)	12 (3.1%)	
Yes	1282 (91.1%)	671 (87.6%)	611 (95.3%)		910 (89.0%)	372 (96.9%)	
Previous Admit Within 30 Days	…	…	…	.78	…	…	.47
No	4172 (85.5%)	3561 (85.4%)	611 (85.8%)		3790 (85.4%)	382 (86.6%)	
Yes	709 (14.5%)	608 (14.6%)	101 (14.2%)		650 (14.6%)	59 (13.4%)	
Admission From SNF	…	…	…	<.0001	…	…	<.0001
No	4580 (93.8)	3967 (95.2)	613 (86.1)		4239 (95.5)	341 (77.3)	
Yes	301 (6.2)	202 (4.9)	99 (13.9)		201 (4.5)	100 (22.7)	

Abbreviations: BMI, body mass index; COVID-19, coronavirus disease 2019; CRP, C-reactive protein; HTN, hypertension; ICU, intensive care unit; Ox, oxygen; P/F, arterial oxygen partial pressure to fractional inspired oxygen; PVHMC, Pomona Valley Hospital Medical Center; RDW, red cell distribution width; SD, standard deviation; SNF, skilled nursing facility.

Table 2. Correlates of Hospital Mortality Among Patients With COVID-19 Hospitalized at PVHMC During 9 March 2020—30 April 2021

Characteristic	Adjusted HR[a] (CI)	*P* Value
Demographics		
Age, Years		
<65	1.0 (ref)	<.0001
≥65	2.66 (1.90–3.72)	
Sex		
Female	1.0 (ref)	
Male	1.31 (1.07–1.60)	.008
Race/Ethnicity		
Asian, Native Hawaiian or Pacific Islander Non-Hispanic/Latino	.81 (.57–1.17)	.26
Black or African American Non-Hispanic/Latino	.65 (.39–1.09)	.1
Hispanic/Latino	.78 (.61–.99)	.04
Other Non-Hispanic/Latino (includes American Indian, Alaska Native)	1.07 (.65–1.76)	.79
White Non-Hispanic/Latino	1.0 (ref)	
Multimember COVID Household		
No	1.0 (ref)	
Yes	.76 (.61–.96)	.02
Comorbidities		
Renal Disease		
No	1.0 (ref)	
Yes	1.52 (1.18–1.95)	.001
Any Cardiovascular Disease		
No	1.0 (ref)	
Yes	1.45 (1.18–1.78)	.0004
Any Neurological Disease/Condition		
No	1.0 (ref)	
Yes	1.84 (1.41–2.39)	<.0001
Laboratory or Clinical Measures		
D-dimer		
<500 ng/mL	1.0 (ref)	
≥500 ng/mL	2.07 (1.43–3.0)	.0001
Glucose		
≤180 mg/dL	1.0 (ref)	
>180 mg/dL	1.11 (.91–1.35)	.32
Pulse Oxygen		
≥88%	1.0 (ref)	
<88%	1.39 (1.13–1.71)	.002

Abbreviations: CI, confidence interval; COVID-19, coronavirus disease 2019; HR, hazard ratio; PVHMC, Pomona Valley Hospital Medical Center; ref, reference group.

[a]Mutually adjusted for other variables in the model.

identification, which may be prone to reporting bias, with individuals tending to overestimate height and underestimate weight [47]. Anecdotally, BMI may not have been obtained at admission if there was a language barrier or if a patient was very ill. Nevertheless, our comorbidity data represent a strength because they were abstracted from physician EMR diagnoses. Unlike other studies [5], we did not rely on *International Classification of Diseases* codes, which are used by hospitals to standardize terminology for billing purposes and do not necessarily establish or reflect diagnoses [48–51].

Elevated glucose was identified as an important risk factor for mortality in our study, whereas diabetes status was not independently associated in models that included glucose level. In a multicenter study in Spain among noncritically hospitalized patients, blood glucose >180 mg/dL was a risk factor of mortality independent of diabetes mellitus [52]. A meta-analysis of 87 studies and including 35 486 patients concluded that diabetes related to worse COVID-19 outcomes, but associated increases in COVID-19 mortality were attenuated when hypertension or chronic kidney disease prevalence were higher [53]. Research has suggested that the relationship between diabetes mellitus and COVID-19 is bidirectional [54]. Severe acute respiratory syndrome coronavirus 2 infection can cause increases in the release of cytokines and other inflammation mediators, which can lead to increased insulin resistance. Conversely, diabetes is associated with chronic inflammation and immune system dysfunction [55]. Persons with diabetes mellitus may have reduced lung function, possibly from oxidative stress associated with the metabolic disorder [55]. In our study, glucose was statistically, significantly, independently associated with mortality in its continuous form but not once scaled to 2 clinically interpretable categories, indicating that a larger sample size was needed to evaluate diabetes mellitus and elevated glucose in the context of other demographic, clinical, and laboratory measures and comorbidities.

In the United States, 5139 community hospitals, half of which are not-for-profit, provide acute and nonacute outpatient, emergency, and inpatient health services. Because the focus of clinicians and other staff is on patient care [56], community hospital populations tend to be excluded from research, with some exceptions [43, 57]. This raises questions about generalizability of findings from studies restricted to academic medical center patients [58]. We are aware of only 2 studies reporting factors that independently predicted hospital mortality in at least 1000 inpatients with COVID-19 from independent US community hospitals without major teaching affiliations [42, 43]. The analysis of 7400 patients at 2 southeastern LAC community hospitals between March 16, 2020 and June 9, 2021, a similar time period to our study, examined more limited predictors, and found age ≥60 years, oxygen saturation <90%, chronic kidney disease, and obesity were associated with increased mortality [42]. Although this report did not provide racial/ethnic or socioeconomic patient data, the primary service area population is 75.7% Latino [59%] and 29% have Medi-Cal, compared with PVHMC with 52.8% Hispanic/Latino race/ethnicity and 39% of patients with Medi-Cal. In addition, 35.7% of the Sato et al [42] patient population had diabetes and 47.2% were obese, compared to 33.8% and 45% in our study, respectively, whereas a higher proportion of our patients had hypertension (43.2%) compared to theirs (33.7%). Thus, despite overall similar hospital and patient characteristics, our dissimilar results for obesity emphasize the importance of additional studies in independent community hospitals without major teaching associations.

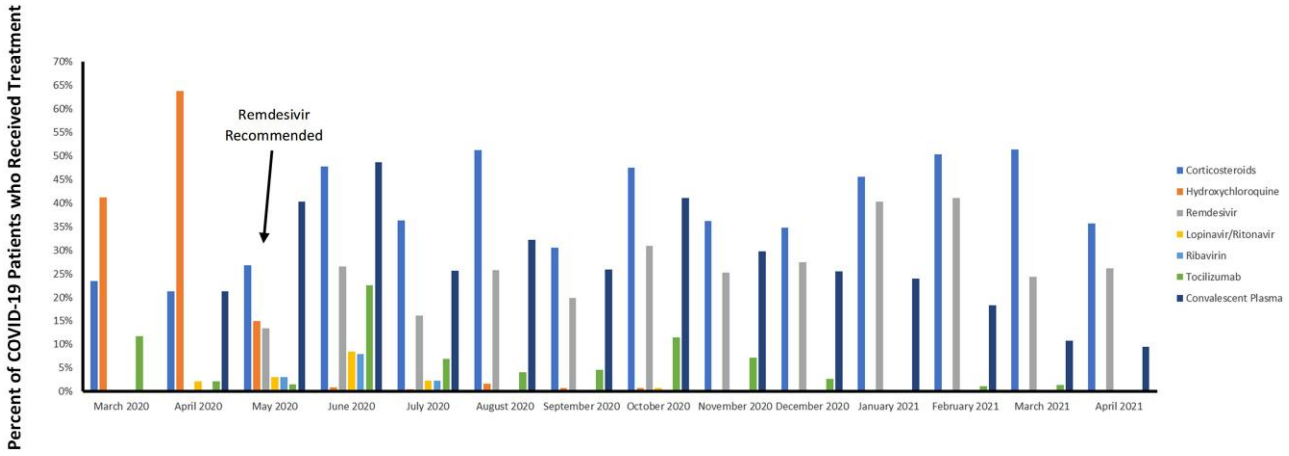

Figure 2. Coronavirus disease 2019 (COVID-19) therapeutic use among patients admitted to hospital by study month, March 2020 to April 2021.

Other studies have reported racial and ethnic disparities in COVID-19 and an increased risk of adverse outcomes among Hispanic/Latino patients with COVID-19 [60–62]. We did not observe Hispanic/Latino patients to be at a greater risk of death compared with non-Hispanic/Latino White patients. Our findings suggest that once hospitalized, Hispanic/Latino patients did not have poorer outcomes than other ethnic or racial groups. This could indicate that hospitals caring for diverse patients can achieve favorable outcomes for Hispanic/Latino patients [63–65]. The proportion of Hispanic/Latino patients among all COVID-19 inpatients (66%) at PVHMC was greater than the proportion of Hispanic/Latino inpatients at PVHMC during 2020 and 2021 (52.8%), suggesting a higher likelihood of community-acquired COVID-19 infection requiring hospitalization among Hispanic/Latino compared to non-Hispanic/Latino patients. Furthermore, the makeup of the non-Hispanic/Latino White comparison group may be a factor because they were an average of 9 years older than Hispanic/Latino patients, and age is consistently strongly associated with mortality among COVID-19 patients [10, 11, 14, 16, 42].

Transmission of SARS-CoV-2 occurs between members of households [66]. Latino households in Baltimore had a secondary attack rate of 45.8%, and higher household transmission was associated with socioeconomic vulnerability, living in poor areas, and denser housing [67]. In our study population, a higher proportion of patients who were Hispanic/Latino reported a multimember COVID-19 household compared with patients of other races/ethnicities. Our observation of reduced hospital mortality from a multiple member COVID-19 household is unique and seems counterintuitive. However, patients who witnessed a sick household member may have been more likely to seek medical care earlier after infection or be encouraged to seek care by their family member with COVID-19. It is also possible that these patients made efforts to reduce the quantitative severity of their SARS-CoV-2 exposure, thus reducing the viral dose of their infection. Evolution of viral virulence during transmission between hosts could be yet another possible explanation for this observation [68, 69].

Our findings of an independent mortality benefit from remdesivir in hypoxic COVID-19 inpatients coincides with findings of the Adaptive COVID-19 Treatment Trial (ACCT)-1 randomized controlled trial, but not the DisCoVeRy trial, negative findings of the SOLIDARITY trial, and a 2021 meta-analysis [70]. More recent observational studies and analyses have shown hospital mortality benefits with remdesivir therapy in the Premier Healthcare Database [71], a reanalysis of the ACCT-1 trial [72], Danish and Italian cohort studies [73, 74], and an elderly Spanish cohort [75], although studies in the elderly population of US veterans hospitals have not detected an associated reduction in mortality [76]. Consistent with several earlier studies of tocilizumab, usually given with corticosteroids [77–80], and a Dutch randomized trial of tocilizumab early in the hospital course of hypoxic COVID-19 patients [81], we also observed an independent mortality benefit associated with tocilizumab treatment in hypoxic COVID-19 inpatients.

Our observation of reduced mortality linked to convalescent plasma transfusion in hypoxic COVID-19 inpatients conflicts with studies finding no benefit [82–85], but it aligns with a retrospective observational study of high-titer convalescent plasma in nonventilated US adult inpatients [86] and the evidence of benefit for high-titer convalescent plasma administration in COVID-19 antibody-negative inpatients [87]. Most of our study convalescent plasma recipients were likely COVID-19 seronegative, because over 90% of PVHMC convalescent plasma use occurred between March 2020 and February 2021, when only 12.1%–24% of LAC blood donors were COVID-19 spike antibody positive [88]. However, our convalescent plasma was not validated as high titer, and our

Table 3. Associations Between Therapeutics and Mortality Among Patients With COVID-19 Hospitalized at PVHMC During March 9, 2020—April 30, 2021

	Overall		Adjusted for All Treatments		Among Hypoxic Patients		Among Hypoxic Patients and Excluding Those With Previous Admission		Among Hypoxic Patients and Adjusted for All Treatments	
Therapeutic	Adjusted HR[a] (CI)	*P* Value	Adjusted HR[a] (CI)	*P* Value	Adjusted HR[a] (CI)	*P* Value	Adjusted HR[a] (CI)	*P* Value	Adjusted HR[a] (CI)	*P* Value
Corticosteroids										
No	1.0 (ref)	.28	1.0 (ref)	.006	1.0 (ref)	.45	1.0 (ref)	.74	1.0 (ref)	.01
Yes	1.37 (.78–2.40)		2.29 (1.26–4.15)		1.28 (.67–2.44)		1.14 (.53–2.45)		2.39 (1.21–4.71)	
Hydroxychloroquine										
No	1.0 (ref)	.13	1.0 (ref)	.10	1.0 (ref)	.09	1.0 (ref)	.008	1.0 (ref)	.11
Yes	1.88 (.82–4.30)		2.03 (.88–4.70)		2.05 (.89–4.71)		3.41 (1.38–8.44)		1.98 (.85–4.60)	
Remdesivir										
No	1.0 (ref)	<.0001	1.0 (ref)	<.0001	1.0 (ref)	<.0001	1.0 (ref)	<.0001	1.0 (ref)	<.0001
Yes	.57 (.44–.76)		.49 (.36–.67)		.53 (.39–.71)		.45 (.33–.63)		.44 (.32–.61)	
Lopinavir/Ritonavir										
No	1.0 (ref)	.69	1.0 (ref)	.66	1.0 (ref)	.59	1.0 (ref)	.98	1.0 (ref)	.62
Yes	.86 (.42–1.77)		.65 (.09–4.59)		.81 (.38–1.74)		.90 (.40–2.45)		.61 (.09–4.29)	
Ribavirin										
No	1.0 (ref)	.65	1.0 (ref)	.98	1.0 (ref)	.54	1.0 (ref)	.92	1.0 (ref)	.96
Yes	.84 (.39–1.80)		1.03 (.13–8.31)		.77 (.34–1.77)		.95 (.34–2.62)		1.06 (.13–8.65)	
Tocilizumab										
No	1.0 (ref)	.06	1.0 (ref)	.048	1.0 (ref)	.02	1.0 (ref)	.03	1.0 (ref)	.02
Yes	.75 (.56–1.01)		.73 (.54–1.00)		.71 (.53–.95)		.69 (.49–.96)		.69 (.50–.94)	
Convalescent Plasma										
No	1.0 (ref)	.002	1.0 (ref)	.06	1.0 (ref)	.0002	1.0 (ref)	.005	1.0 (ref)	.02
Yes	.66 (.51–.86)		.77 (.58–1.02)		.60 (.45–.78)		.65 (.49–.88)		.72 (.54–.96)	

Abbreviations: CI, confidence interval; COVID-19, coronavirus disease 2019; HR, hazard ratio; PVHMC, Pomona Valley Hospital Medical Center; ref, reference group.

[a]Adjusted for age, sex, race/ethnicity, chronic renal disease, cardiovascular disease, neurological disease, glucose (≥200 mg/dL vs <200 mg/dL), D-dimer (≥500 vs <500).

recipients were not confirmed to be COVID-19 spike antibody negative, so it is uncertain whether our findings were due to optimized matching of high-titer convalescent plasma to seronegative recipients.

In contrast with the demonstrated mortality benefit of corticosteroid therapy for moderate to severe COVID-19 reported in the large, randomized, controlled RECOVERY trial [89] and meta-analyses of randomized controlled studies [90–92], we found increased mortality associated with receipt of corticosteroid therapy independent from other risk factors and treatments in our patient population. However, increased mortality associated with corticosteroid therapy in patients hospitalized with COVID-19 has been reported in retrospective observational studies [93, 94] and a meta-analysis of retrospective studies [92]. Thus, our finding may be a result of our retrospective design or due to unaccounted variability in disease severity and duration, corticosteroid timing, dose, indication, and days of therapy, because anecdotally we observed corticosteroid prescriptions substantially incongruent with recommended regimens [95] in our population (D. G., unpublished observations, 2022). Other explanations include surges in inpatients with COVID-19, as has been previously reported during the time period of our study [96, 97], particularly in Hispanic/Latino patients [96] and for community hospitals [97]. Our observation of increased COVID-19 mortality associated with temporal surges in COVID-19 inpatients at our hospital supports this possibility.

Our study is limited in that we did not have data on date of symptom onset nor how long patients had been ill before presenting at our hospital; thus, we could not account for these factors as covariables in regression models. This information may have been particularly important for initiation of therapeutics and interpretation of results for available therapies. We lacked information on previous COVID-19 infection and vaccination status, both of which could explain better outcomes. Vaccination would have only been relevant to patients hospitalized after vaccines became available to the California public in phases beginning early 2021 based on age, occupation, and underlying health conditions [98]. We also lacked data on socioeconomic factors or smoking status, and thus we could not examine these characteristics. Patients with a smoking history have an increased risk of in-hospital mortality [99]. Our classification of hypoxic came from measurements obtained at admission; we did not have data to examine how status may have changed over the course of their stay. Our study was conducted when Alpha, Epsilon, and Gamma were the major prevalent variants in California [100, 101]. As such, the generalizability of our research may not extend to examinations of mortality among patients with COVID-19 variants such as Delta or Omicron, which vary in transmissibility, virulence,

and resistance to vaccines and therapeutics, among other characteristics.

CONCLUSIONS

In a community hospital with predominantly Hispanic/Latino adult inpatients with COVID-19, a high fraction of whom were covered by Medicaid, we corroborated several previously identified mortality risk factors, but we found unique variations, providing evidence that factors defined in academic medical center cohorts or large multihospital databases may not be applicable in divergent settings and populations.

Supplementary Data

Supplementary materials are available at *Open Forum Infectious Diseases* online. Consisting of data provided by the authors to benefit the reader, the posted materials are not copyedited and are the sole responsibility of the authors, so questions or comments should be addressed to the corresponding author.

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Potential conflicts of interest. All authors: No reported potential conflicts of interest.

References

1. Chen R, Liang W, Jiang M, et al. Risk factors of fatal outcome in hospitalized subjects with coronavirus disease 2019 from a nationwide analysis in China. Chest **2020**; 158:97–105.
2. Liang W, Liang H, Ou L, et al. Development and validation of a clinical risk score to predict the occurrence of critical illness in hospitalized patients with COVID-19. JAMA Intern Med **2020**; 180:1081–9.
3. Cummings MJ, Baldwin MR, Abrams D, et al. Epidemiology, clinical course, and outcomes of critically ill adults with COVID-19 in New York City: a prospective cohort study. Lancet **2020**; 395:1763–70.
4. Gupta S, Hayek SS, Wang W, et al. Factors associated with death in critically ill patients with coronavirus disease 2019 in the US. JAMA Intern Med **2020**; 180: 1436–47.
5. Kompaniyets L, Pennington AF, Goodman AB, et al. Underlying medical conditions and severe illness among 540,667 adults hospitalized with COVID-19, March 2020-March 2021. Prev Chronic Dis **2021**; 18:E66.
6. Grasselli G, Greco M, Zanella A, et al. Risk factors associated with mortality among patients with COVID-19 in intensive care units in Lombardy, Italy. JAMA Intern Med **2020**; 180:1345–55.
7. Knight SR, Ho A, Pius R, et al. Risk stratification of patients admitted to hospital with covid-19 using the ISARIC WHO clinical characterisation protocol: development and validation of the 4C mortality score. BMJ **2020**; 370:m3339.
8. Ge E, Li Y, Wu S, Candido E, Wei X. Association of pre-existing comorbidities with mortality and disease severity among 167,500 individuals with COVID-19 in Canada: a population-based cohort study. PLoS One **2021**; 16:e0258154.
9. Chidambaram V, Tun NL, Haque WZ, et al. Factors associated with disease severity and mortality among patients with COVID-19: a systematic review and meta-analysis. PLoS One **2020**; 15:e0241541.
10. de Jong VMT, Rousset RZ, Antonio-Villa NE, et al. Clinical prediction models for mortality in patients with covid-19: external validation and individual participant data meta-analysis. BMJ **2022**; 378:e069881.
11. Dessie ZG, Zewotir T. Mortality-related risk factors of COVID-19: a systematic review and meta-analysis of 42 studies and 423,117 patients. BMC Infect Dis **2021**; 21:1–28.
12. Du Y, Zhou N, Zha W, Lv Y. Hypertension is a clinically important risk factor for critical illness and mortality in COVID-19: a meta-analysis. Nutr Metab Cardiovasc Dis **2021**; 31:745–55.
13. Fathi M, Vakili K, Sayehmiri F, et al. The prognostic value of comorbidity for the severity of COVID-19: a systematic review and meta-analysis study. PLoS One **2021**; 16:e0246190.
14. Galanter W, Rodríguez-Fernández JM, Chow K, et al. Predicting clinical outcomes among hospitalized COVID-19 patients using both local and published models. BMC Med Inform Decis Mak **2021**; 21:224.
15. Katzenschlager S, Zimmer AJ, Gottschalk C, et al. Can we predict the severe course of COVID-19—a systematic review and meta-analysis of indicators of clinical outcome? PLoS One **2021**; 16:e0255154.
16. Mesas AE, Cavero-Redondo I, Alvarez-Bueno C, et al. Predictors of in-hospital COVID-19 mortality: a comprehensive systematic review and meta-analysis exploring differences by age, sex and health conditions. PLoS One **2020**; 15: e0241742.
17. Pijls BG, Jolani S, Atherley A, et al. Demographic risk factors for COVID-19 infection, severity, ICU admission and death: a meta-analysis of 59 studies. BMJ Open **2021**; 11:e044640.
18. Shi C, Wang L, Ye J, et al. Predictors of mortality in patients with coronavirus disease 2019: a systematic review and meta-analysis. BMC Infect Dis **2021**; 21: 663.
19. Wynants L, Van Calster B, Collins GS, et al. Prediction models for diagnosis and prognosis of covid-19: systematic review and critical appraisal. BMJ **2020**; 369: m1328.
20. Zheng Z, Peng F, Xu B, et al. Risk factors of critical & mortal COVID-19 cases: a systematic literature review and meta-analysis. J Infect **2020**; 81:e16–25.
21. Kim HJ, Hwang H, Hong H, Yim JJ, Lee J. A systematic review and meta-analysis of regional risk factors for critical outcomes of COVID-19 during early phase of the pandemic. Sci Rep **2021**; 11:9784.
22. Zhang L, Hou J, Ma FZ, Li J, Xue S, Xu ZG. The common risk factors for progression and mortality in COVID-19 patients: a meta-analysis. Arch Virol **2021**; 166:2071–87.
23. US Census Bureau. Quick Facts, Los Angeles County, California. US Department of Commerce. Available at: https://www.census.gov/quickfacts/fact/table/losangelescountycalifornia,US/RHI725221. Accessed September 25, 2022.
24. Johns Hopkins University & Medicine Coronavirus Resource Center. Available from: https://coronavirus.jhu.edu/. Accessed 17 April 2022.
25. Horn AL, Jiang L, Washburn F, et al. An integrated risk and epidemiological model to estimate risk-stratified COVID-19 outcomes for Los Angeles County: March 1, 2020-March 1, 2021. PLoS One **2021**; 16:e0253549.
26. Dong YM, Sun J, Li YX, et al. Development and validation of a nomogram for assessing survival in patients with COVID-19 pneumonia. Clin Infect Dis **2021**; 72:652–60.
27. Du P, Li D, Wang A, Shen S, Ma Z, Li X. A systematic review and meta-analysis of risk factors associated with severity and death in COVID-19 patients. Can J Infect Dis Med Microbiol **2021**; 2021:6660930.
28. Fried MW, Crawford JM, Mospan AR, et al. Patient characteristics and outcomes of 11 721 patients with coronavirus disease 2019 (COVID-19) hospitalized across the United States. Clin Infect Dis **2021**; 72:e558–65.
29. Petrilli CM, Jones SA, Yang J, et al. Factors associated with hospital admission and critical illness among 5279 people with coronavirus disease 2019 in New York City: prospective cohort study. BMJ **2020**; 369:m1966.
30. Rahman A, Sathi NJ. Risk factors of the severity of COVID-19: a meta-analysis. Int J Clin Pract **2021**; 75:e13916.
31. Vera-Zertuche JM, Mancilla-Galindo J, Tlalpa-Prisco M, et al. Obesity is a strong risk factor for short-term mortality and adverse outcomes in Mexican patients with COVID-19: a national observational study. Epidemiol Infect **2021**; 149: e109.
32. Wu JT, Leung K, Bushman M, et al. Estimating clinical severity of COVID-19 from the transmission dynamics in Wuhan, China. Nat Med **2020**; 26:506–10.
33. Yan L, Zhang H-T, Goncalves J, et al. An interpretable mortality prediction model for COVID-19 patients. Nat Mach Intell **2020**; 2:283–8.
34. Zhang JJY, Lee KS, Ang LW, Leo YS, Young BE. Risk factors for severe disease and efficacy of treatment in patients infected with COVID-19: a systematic review, meta-analysis, and meta-regression analysis. Clin Infect Dis **2020**; 71: 2199–206.

35. University of Wisconsin Population Health Institute. 2022 County Health Rankings National Findings Report. Available at: https://www.countyhealthrankings.org/app/california/2022/measure/factors/11/data. Accessed September 8, 2022.
36. Singh R, Rathore SS, Khan H, et al. Association of obesity with COVID-19 severity and mortality: an updated systemic review, meta-analysis, and meta-regression. Front Endocrinol (Lausanne) **2022**; 13:780872.
37. Asch DA, Sheils NE, Islam MN, et al. Variation in US hospital mortality rates for patients admitted with COVID-19 during the first 6 months of the pandemic. JAMA Intern Med **2021**; 181:471–8.
38. Babar I, Ekenna O, Clarkson MR, Boudreaux D, Bennett W, Roth R. COVID-19 in a Mississippi community hospital. South Med J **2021**; 114:305–10.
39. Kompaniyets L, Goodman AB, Belay B, et al. Body mass index and risk for COVID-19-related hospitalization, intensive care unit admission, invasive mechanical ventilation, and death—United States, March-December 2020. MMWR Morb Mortal Wkly Rep **2021**; 70:355–61.
40. Moon RC, Mackey RH, Cao Z, et al. Is coronavirus disease 2019 (COVID-19) less deadly now? Trends in in-hospital mortality among hospitalized COVID-19 patients in the United States. Clin Infect Dis **2022**; 74:2238–42.
41. Nau C, Bruxvoort K, Navarro RA, et al. COVID-19 Inequities across multiple racial and ethnic groups: results from an integrated health care organization. Ann Intern Med **2021**; 174:1183–6.
42. Sato A, Ludwig J, Howell T. A retrospective cohort study on COVID-19 at 2 Los Angeles hospitals: older age, low triage oxygenation, and chronic kidney disease among the top risk factors associated with in-hospital mortality. PLoS One **2022**; 17:e0268688.
43. Takahashi M, Egorova NN, Iwagami M, Kuno T. Hospital factor and prognosis of COVID-19 in New York City, the United States of America: insights from a retrospective cohort study. BMC Health Serv Res **2022**; 22:164.
44. Tartof SY, Qian L, Hong V, et al. Obesity and mortality among patients diagnosed with COVID-19: results from an integrated health care organization. Ann Intern Med **2020**; 173:773–81.
45. Velasco JM, Tseng WC, Chang CL. Factors affecting the cases and deaths of COVID-19 victims. Int J Environ Res Public Health **2021**; 18:674.
46. Zhou Y, Yang Q, Chi J, et al. Comorbidities and the risk of severe or fatal outcomes associated with coronavirus disease 2019: a systematic review and meta-analysis. Int J Infect Dis **2020**; 99:47–56.
47. Ossiander EM, Emanuel I, O'Brien W, Malone K. Driver's licenses as a source of data on height and weight. Econ Hum Biol **2004**; 2:219–27.
48. Januel JM, Luthi JC, Quan H, et al. Improved accuracy of co-morbidity coding over time after the introduction of ICD-10 administrative data. BMC Health Serv Res **2011**; 11:194.
49. Martin BJ, Chen G, Graham M, Quan H. Coding of obesity in administrative hospital discharge abstract data: accuracy and impact for future research studies. BMC Health Serv Res **2014**; 14:70.
50. Mocarski M, Tian Y, Smolarz BG, McAna J, Crawford A. Use of international classification of diseases, ninth revision codes for obesity: trends in the United States from an electronic health record-derived database. Popul Health Manag **2018**; 21:222–30.
51. Suissa K, Schneeweiss S, Lin KJ, Brill G, Kim SC, Patorno E. Validation of obesity-related diagnosis codes in claims data. Diabetes Obes Metab **2021**; 23: 2623–31.
52. Carrasco-Sanchez FJ, Lopez-Carmona MD, Martinez-Marcos FJ, et al. Admission hyperglycaemia as a predictor of mortality in patients hospitalized with COVID-19 regardless of diabetes status: data from the Spanish SEMI-COVID-19 registry. Ann Med **2021**; 53:103–16.
53. Corona G, Pizzocaro A, Vena W, et al. Diabetes is most important cause for mortality in COVID-19 hospitalized patients: systematic review and meta-analysis. Rev Endocr Metab Disord **2021**; 22:275–96.
54. Nassar M, Daoud A, Nso N, et al. Diabetes mellitus and COVID-19: review article. Diabetes Metab Syndr **2021**; 15:102268.
55. Zhou Y, Chi J, Lv W, Wang Y. Obesity and diabetes as high-risk factors for severe coronavirus disease 2019 (Covid-19). Diabetes Metab Res Rev **2021**; 37:e3377.
56. Gehrke P, Binnie A, Chan SPT, et al. Fostering community hospital research. CMAJ **2019**; 191:E962–6.
57. Lee S, Santarelli A, Caine K, Schritter S, Dietrich T, Ashurst J. Remdesivir for the treatment of severe COVID-19: a community hospital's experience. J Am Osteopath Assoc **2020**; 120:926–33.
58. Gianattasio KZ, Bennett EE, Wei J, et al. Generalizability of findings from a clinical sample to a community-based sample: a comparison of ADNI and ARIC. Alzheimers Dement **2021**; 17:1265–76.
59. PIH Health Hospital—Downey. 2019 *Community Health Needs Assessment*. Available at: https://www.pihhealth.org/app/files/public/32f3d083-92f0-4408-8dda-e6a62166006b/2019-CHNA-Downey.pdf. Accessed September 1, 2022.
60. Acosta AM, Garg S, Pham H, et al. Racial and ethnic disparities in rates of COVID-19-associated hospitalization, intensive care unit admission, and in-hospital death in the United States from March 2020 to February 2021. JAMA Netw Open **2021**; 4:e2130479.
61. Poulson M, Neufeld M, Geary A, et al. Intersectional disparities among Hispanic groups in COVID-19 outcomes. J Immigr Minor Health **2021**; 23:4–10.
62. Ricardo AC, Chen J, Toth-Manikowski SM, et al. Hispanic ethnicity and mortality among critically ill patients with COVID-19. PLoS One **2022**; 17:e0268022.
63. Krishnamoorthy G, Arsene C, Jena N, et al. Racial disparities in COVID-19 hospitalizations do not lead to disparities in outcomes. Public Health **2021**; 190: 93–8.
64. Mackey K, Ayers CK, Kondo KK, et al. Racial and ethnic disparities in COVID-19-related infections, hospitalizations, and deaths: a systematic review. Ann Intern Med **2021**; 174:362–73.
65. Navar AM, Purinton SN, Hou Q, Taylor RJ, Peterson ED. The impact of race and ethnicity on outcomes in 19,584 adults hospitalized with COVID-19. PLoS One **2021**; 16:e0254809.
66. Madewell ZJ, Yang Y, Longini IM, Halloran ME Jr, Dean NE. Household transmission of SARS-CoV-2: a systematic review and meta-analysis. JAMA Netw Open **2020**; 3:e2031756.
67. Martinez DA, Klein EY, Parent C, et al. Latino household transmission of severe acute respiratory syndrome coronavirus 2. Clin Infect Dis **2022**; 74:1675–7.
68. Cressler CE, Mc LD, Rozins C JVDH, Day T. The adaptive evolution of virulence: a review of theoretical predictions and empirical tests. Parasitology **2016**; 143:915–30.
69. Alizon S, Sofonea MT. SARS-CoV-2 virulence evolution: avirulence theory, immunity and trade-offs. J Evol Biol **2021**; 34:1867–77.
70. Crichton ML, Goeminne PC, Tuand K, et al. The impact of therapeutics on mortality in hospitalised patients with COVID-19: systematic review and meta-analyses informing the European Respiratory Society living guideline. Eur Respir Rev **2021**; 30:210171.
71. Mozaffari E, Chandak A, Zhang Z, et al. Remdesivir treatment in hospitalized patients with coronavirus disease 2019 (COVID-19): a comparative analysis of in-hospital all-cause mortality in a large multicenter observational cohort. Clin Infect Dis **2022**; 75:e450–8.
72. Paules CI, Gallagher SK, Rapaka RR, et al. Remdesivir for the prevention of invasive mechanical ventilation or death in coronavirus disease 2019 (COVID-19): a post hoc analysis of the Adaptive COVID-19 Treatment Trial-1 cohort data. Clin Infect Dis **2022**; 74:1260–4.
73. Benfield T, Bodilsen J, Brieghel C, et al. Improved survival among hospitalized patients with coronavirus disease 2019 (COVID-19) treated with remdesivir and dexamethasone. A nationwide population-based cohort study. Clin Infect Dis **2021**; 73:2031–6.
74. Marrone A, Nevola R, Sellitto A, et al. Remdesivir plus dexamethasone versus dexamethasone alone for the treatment of coronavirus disease 2019 (COVID-19) patients requiring supplemental O2 therapy: a prospective controlled nonrandomized study. Clin Infect Dis **2022**; 75:e403–9.
75. Ramos-Rincon JM, Lopez-Carmona MD, Cobos-Palacios L, et al. Remdesivir in very old patients (>/=80 years) hospitalized with COVID-19: real world data from the SEMI-COVID-19 registry. J Clin Med **2022**; 11:3769 .
76. Ohl ME, Miller DR, Lund BC, et al. Association of remdesivir treatment with survival and length of hospital stay among US veterans hospitalized with COVID-19. JAMA Netw Open **2021**; 4:e2114741.
77. Investigators R-C, Gordon AC, Mouncey PR, et al. Interleukin-6 receptor antagonists in critically ill patients with COVID-19. N Engl J Med **2021**; 384: 1491–502.
78. Rosas IO, Brau N, Waters M, et al. Tocilizumab in hospitalized patients with severe COVID-19 pneumonia. N Engl J Med **2021**; 384:1503–16.
79. Group RC. Tocilizumab in patients admitted to hospital with COVID-19 (RECOVERY): a randomised, controlled, open-label, platform trial. Lancet **2021**; 397:1637–45.
80. Salama C, Han J, Yau L, et al. Tocilizumab in patients hospitalized with COVID-19 pneumonia. N Engl J Med **2021**; 384:20–30.
81. Rutgers A, Westerweel PE, van der Holt B, et al. Timely administration of tocilizumab improves outcome of hospitalized COVID-19 patients. PLoS One **2022**; 17:e0271807.
82. Begin P, Callum J, Jamula E, et al. Convalescent plasma for hospitalized patients with COVID-19: an open-label, randomized controlled trial. Nat Med **2021**; 27: 2012–24.
83. Chauhan L, Pattee J, Ford J, et al. A multicenter, prospective, observational, cohort-controlled study of clinical outcomes following coronavirus disease 2019 (COVID-19) convalescent plasma therapy in hospitalized patients with COVID-19. Clin Infect Dis **2022**; 75:e466–72.

84. De Santis GC, Oliveira LC, Garibaldi PMM, et al. High-dose convalescent plasma for treatment of severe COVID-19. Emerg Infect Dis **2022**; 28:548–55.
85. Simonovich VA, Burgos Pratx LD, Scibona P, et al. A randomized trial of convalescent plasma in Covid-19 severe pneumonia. N Engl J Med **2021**; 384: 619–29.
86. Joyner MJ, Carter RE, Senefeld JW, et al. Convalescent plasma antibody levels and the risk of death from Covid-19. N Engl J Med **2021**; 384:1015–27.
87. Estcourt LJ, Cohn CS, Pagano MB, et al. Clinical practice guidelines from the Association for the Advancement of Blood and Biotherapies (AABB): COVID-19 convalescent plasma. Ann Intern Med **2022**; 175:1310–21.
88. Jones JM, Stone M, Sulaeman H, et al. Estimated US infection- and vaccine-induced SARS-CoV-2 seroprevalence based on blood donations, July 2020-May 2021. JAMA **2021**; 326:1400–9.
89. Group RC, Horby P, Lim WS, et al. Dexamethasone in hospitalized patients with Covid-19. N Engl J Med **2021**; 384:693–704.
90. WHO Rapid Evidence Appraisal for COVID-19 Therapies (REACT) Working Group; Sterne JAC, Murthy S, et al. Association between administration of systemic corticosteroids and mortality among critically ill patients with COVID-19: a meta-analysis. JAMA **2020**; 324:1330–41.
91. Patel C, Parmar K, Patel D, Patel S, Sheth D, Beladiya JV. Effect of corticosteroid therapy on mortality in COVID-19 patients-A systematic review and meta-analysis. Rev Med Virol **2022**; 32:e2386.
92. Wagner C, Griesel M, Mikolajewska A, et al. Systemic corticosteroids for the treatment of COVID-19: equity-related analyses and update on evidence. Cochrane Database Syst Rev **2022**; 11:CD014963.
93. Alotaibi N, Alroomi M, Aboelhassan W, et al. In-hospital mortality in SARS-CoV-2 stratified by the use of corticosteroid. Ann Med Surg (Lond) **2022**; 80:104105.
94. Liu J, Zhang S, Dong X, et al. Corticosteroid treatment in severe COVID-19 patients with acute respiratory distress syndrome. J Clin Invest **2020**; 130:6417–28.
95. National Institutes of Health. Coronavirus Disease (COVID-19) Treatment Guidelines. Available at: https://www.covid19treatmentguidelines.nih.gov/. Accessed July 22, 2022.
96. Kadri SS, Sun J, Lawandi A, et al. Association between caseload surge and COVID-19 survival in 558 U.S. hospitals, March to August 2020. Ann Intern Med **2021**; 174:1240–51.
97. Patel B, Murphy RE, Karanth S, et al. Surge in incidence and coronavirus disease 2019 hospital risk of death, United States, September 2020 to March 2021. Open Forum Infect Dis **2022**; 9:ofac424.
98. California Department Public Health. Updated COVID-19 Vaccine Eligibility Guidelines. Available at: https://www.cdph.ca.gov/Programs/CID/DCDC/Pages/COVID-19/VaccineAllocationGuidelines.aspx. Accessed October 1, 2022.
99. Reddy RK, Charles WN, Sklavounos A, Dutt A, Seed PT, Khajuria A. The effect of smoking on COVID-19 severity: a systematic review and meta-analysis. J Med Virol **2021**; 93:1045–56.
100. California Department Public Health. Variants in California. Available at: https://covid19.ca.gov/variants/. Accessed November 13, 2022.
101. Elbe S, Buckland-Merrett G. Data, disease and diplomacy: GISAID's innovative contribution to global health. Glob Chall **2017**; 1:33–46.