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Characteristics and clinical outcomes of COVID-19 patients in an underserved-inner city population: A single tertiary center cohort

Grace Salacup MD[1] [iD] | Kevin Bryan Lo MD[1] | Fahad Gul MD[1] | Eric Peterson DO[1] | Robert De Joy III DO[1] | Ruchika Bhargav DO[1] | Jerald Pelayo MD[1] | Jeri Albano MD[1] | Zurab Azmaiparashvili MD, MSc[1] | Sadia Benzaquen MD[1,2] | Gabriel Patarroyo-Aponte MD[1,2] | Janani Rangaswami MD[1,3]

[1]Department of Medicine, Einstein Medical Center Philadelphia, Philadelphia, Pennsylvania

[2]Division of Pulmonary and Critical Care and Sleep Medicine, Einstein Medical Center Philadelphia, Philadelphia, Pennsylvania

[3]Sidney Kimmel College of Thomas Jefferson University, Philadelphia, Pennsylvania

Correspondence
Grace Salacup MD, Einstein Medical Center, Philadelphia, 5501 Old York Road Philadelphia PA 19141.
Email: salacupg@einstein.edu

Abstract

There is limited information describing the characteristics and clinical outcomes of patients infected with coronavirus disease 2019 (COVID-19) especially those in underserved urban area with minority population in the United States. This is a retrospective single-center study for patients who were admitted with COVID-19 infection. Data collection was from 1 March through 24 April 2020. Demographic, clinical, laboratory, and treatment data were presented using descriptive statistics and frequencies. The χ^2 test and multivariate logistic regression were used to determine association of risk factors and clinical outcomes. A total of 242 inpatients were included with a mean age of 66 ± 14.75 (±standard deviation). A total of 50% were female and 70% were African American. Comorbidities included hypertension (74%), diabetes mellitus (49%), and 19% had either COPD or asthma. Older age was associated with higher risk of inpatient death odds ratio (OR): 1.056 (95% confidence interval [CI]: 1.023-1.090; P = .001). Inpatient mortality occurred in 70% who needed mechanical ventilation (OR: 29.51; 95% CI: 13.28-65.60; P < .0001), 58% who required continuous renal replacement therapy/hemodialysis (CRRT/HD) (OR: 6.63; 95% CI: 2.74-16.05; P < .0001), and 69% who needed vasopressors (OR: 30.64; 95% CI: 13.56-69.20; P < .0001). Amongst biomarkers of disease severity, only baseline CRP levels (145 ± 116 mg/L) were associated with mortality OR: 1.008 (95% CI: 1.003-1.012; P = .002). Majority of hospitalized patients had hypertension and diabetes. Older age was an independent risk factor for inpatient mortality. Requirement of mechanical ventilation, vasopressor use, and CRRT/HD was associated significantly with inpatient mortality. Higher baseline CRP was significantly associated with inpatient death.

KEYWORDS
coronavirus, COVID-19, inner city hospital, outcomes

1 | INTRODUCTION

Severe acute respiratory syndrome coronavirus-2 (SARS-CoV-2) or coronavirus disease 2019 (COVID-19) is the novel coronavirus that was first detected in Wuhan, Hubei, China which has rapidly spread in different countries within a few months and now is considered as a pandemic threat.[1] As of 2 May 2020, this virus has affected 3 420 000 globally, with over a million confirmed cases in the United States (US).[2] Philadelphia ranked 13th (15 137)[2] amongst US counties with the most number of confirmed cases, with majority of the affected population being elderly nursing home residents.[3] Einstein Healthcare Network is an inner city urban community hospital in Northern Philadelphia and has admitted a large proportion of COVID-19 patients in the area. At the time of data analysis, there were approximately 15 137 cases in Philadelphia county, which was before the peak period. Einstein Medical Center had a total of 237 admitted COVID-19 patients to which 106 were confirmed and 131 were suspected.[4] There are limited and underrepresented data with regards to previous COVID-19 studies that describe the clinical characteristics of COVID-19 patients in minority population such as African Americans, Hispanic, and Asians. The primary objective of this analysis was to describe the general demographics and clinical factors of COVID-19 inpatients of a minority population in an underserved area. It aimed to describe their clinical outcomes namely (a) inpatient mortality, (b) need for mechanical ventilation, (c) need for vasopressors, and (d) need for continuous renal replacement therapy (CRRT)/hemodialysis (HD). The secondary objective was to determine association of these clinical factors with the respective clinical outcomes in this special population.

2 | PATIENTS AND METHODS

2.1 | Study design, participants, and data collection

This study was a single-center retrospective case series during 1 March to 24 April 2020. Included were all patients more than 18 years old with a confirmed diagnosis of COVID-19 via reverse transcriptase-polymerase chain reaction assays. Samples were obtained by nasopharyngeal swab or a closed endotracheal suction by Lukens. We included data from patients that were either discharged or who died. We excluded patients who were still inpatient as of the chart-review and those who had incomplete data on clinical outcomes thus only those who were either discharged or who died were included in the study. We also excluded patients on Remdesivir or convalescent plasma as these were recently introduced treatments and patients who were on this were still inpatient at the time of analysis and did not have the desired clinical outcomes yet. The primary outcome was inpatient mortality and the secondary outcomes were need for vasopressors, CRRT/HD, and mechanical ventilation. Demographic, clinical characteristics, laboratory, and treatment data were extracted from electronic medical records with a standardized data collection form. Informed consent was waived

since this was a retrospective study. IRB approval was obtained with an IRB number: 2020-436.

2.2 | Statistical analysis

Demographic variables were presented using descriptive statistics and frequencies. Categorical variables were analyzed with χ^2 testing. Demographic and clinical variables were tabulated. Stratification of inpatient death and need for intubation by quartile of age were included. The χ^2 was used to analyze the relationship between demographic or comorbidity variables and inpatient death, need for intubation, need for CRRT/HD, and vasopressor use. Multivariate logistic regression was used to look at the factors associated with inpatient mortality as primary outcome, and need for vasopressors, CRRT/HD, and mechanical ventilation as secondary outcomes. Separate multivariate logistic regression was also done for each inflammatory marker as there are concerns of collinearity. These inflammatory markers may be highly correlated with one another going in the same direction based on increasing disease severity, thus, they may potentially alter the results and predictive effects. P value of less than .05 was considered significant. 95% confidence intervals (CIs) were used and are presented when appropriate.

3 | RESULTS

3.1 | Demographic and comorbidities of the patients

A total of 389 patients were evaluated in our hospital and tested positive via PCR for COVID-19. A total of 122 patients were excluded from data analysis as they were still admitted at the time of data analysis as clinical outcomes specifically inpatient death, and need for vasopressors, CRRT/HD and mechanical ventilation cannot be fully elicited. Also, 25 patients with incomplete data were excluded leaving a final sample of 242 patients analyzed (see Figure 1). In the final sample of 242 patients (see Table 1), the mean age (±standard deviation) was 66 ± 14.75, 49% were females, and 70% were African Americans. Chronic medical conditions of these patients include hypertension (74%), diabetes mellitus (49%), and 19% had either COPD or asthma. There were no statistically significant differences in the rates of diabetes and hypertension compared to clinical outcomes respectively when stratified by sex. However, there was a significantly higher rate of obesity (body mass index [BMI] >30) in females compared to males (51% vs 29%; P = .001) (see Table S1). In terms of race, even though there was a statistically significant higher rates of obesity among African Americans compared to other races (47% vs 30%; P = .007), there were no differences in the rates of hypertension or diabetes compared to other races (see Table S2). Mean BMI was 29.32 ± 9.22 kg/m^2 with 40% of our population were obese (BMI >30 kg/m^2).
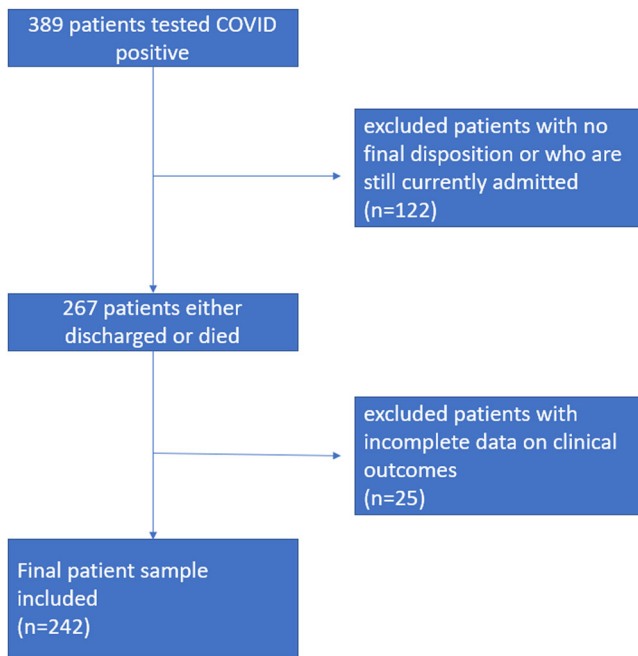
FIGURE 1 Consort diagram

3.2 | Clinical and laboratory parameters on admission, and COVID-19 treatment

Mean FiO_2% requirement was 39% on admission with higher mean FiO_2 requirement (80%) amongst patient who died ($P < .001$). Inflammatory markers such as CRP, procalcitonin, and LDH were more elevated on admission among those who had inpatient mortality ($P < .001$). A total of 60% received hydroxychloroquine, 23% received steroids, and less than 10% received the interleukin-6 (IL-6) inhibitor tocilizumab. There were significantly higher rates of hydroxychloroquine and steroids treatment among patients who died (See Table 1).

3.3 | Primary and secondary clinical outcomes

Inpatient mortality as primary outcome was 52 out of 242 (21%). Secondary outcomes namely need for CRRT/HD, vasopressors, and mechanical ventilation were 10%, 20%, and 22%, respectively. A total of 14 out of 24 (58%) who required CRRT/HD, 36 out of 49 (69%) who needed vasoactive pressor, and 38 out of 54 (73%) who needed mechanical ventilation had inpatient mortality ($P < .0001$).

3.4 | Association of baseline characteristic, comorbidities, clinical, and laboratory parameters to clinical outcomes

Multivariable logistic regression was performed to determine independent predictors of the primary and secondary outcomes. For primary outcome, only age was significantly associated with a higher risk of inpatient death odds ratio (OR): 1.056 (95% CI: 1.023-1.090; $P = .001$) (see Table 2). As described in Table 1, mean age was significantly higher in patients who died compared to those who survived (73.15 ± 11.01 vs 64.08 ± 15.07; $P < .0001$). Going up progressively from the age quartiles, the rates of death were statistically significantly increased from 5% to as high as 35% in the oldest quartile age group ($P < .0001$). In fact, over 94% of patients who died in our sample population were 58 years old and above. There were also trends towards increased mechanical ventilation in the older age quartiles, but this was not statistically significant ($P = .077$) (see Figure 2). Mean FiO_2 on admission was also higher on admission among nonsurvivors compared to survivors (80% vs 21%; $P < .0001$). For secondary outcomes, there were no baseline characteristics, comorbidities, clinical, or laboratory parameters on admission that were significantly associated with the need for CRRT/HD, vasopressors, or mechanical ventilation. Though there were trends towards significance for diabetes and need for vasopressors OR: 2.139 (95% CI: 0.996-4.595; $P = .051$) and for history of heart failure and need for CRRT/HD OR: 3.238 (95% CI: 0.999-10.490; $P = .05$) (see Table S3).

3.5 | Association of baseline inflammatory markers and inpatient death

Multivariable logistic regression was performed separately to evaluate the association of inflammatory baseline markers with primary outcome as inpatient death. Only CRP levels at baseline were significantly associated OR: 1.008 (95% CI: 1.003-1.012; $P = .002$) (see Table 3). Baseline mean CRP among patients who died were significantly higher compared to those who survived (186 vs 100 mg/dL; $P < .0001$) (see Table 1).

3.6 | Association of COVID-19 specific treatments with clinical outcomes

In terms of associations of COVID-19 specific treatments to clinical outcomes, there were poorer clinical outcomes associated with the use of tocilizumab, steroids, and hydroxychloroquine. Use of Tocilizumab was significantly associated with need for intubation (62% vs 19%; $P < .0001$) and vasopressor use (43% vs 18%; $P = .019$). Likewise, the use of steroids and hydroxychloroquine were significantly associated with inpatient death, need for intubation, CRRT/HD, and vasopressor use (see Table 4).

4 | DISCUSSION

In this retrospective single-center study, clinical characteristics were described, and risk factors were determined in association with inpatient death, need for intubation, need for CRRT/HD, and

TABLE 1 Clinical characteristic of the patients at baseline

Characteristics	Total (N = 242) n (%)	Died (N = 52) n (%)	Survived (N = 190) n (%)	P value
Age median (IQR)	66 (58-76)	73.15 ± 11.01	64.08 ± 15.07	<.0001
Female gender	119 (49)	25 (48)	94(50)	.8770
Ethnicity				.188
African American	171 (70)	34 (65)	137 (72)	
Caucasian	17 (7)	3 (6)	14 (7)	
Hispanic	26 (11)	4 (8)	22 (12)	
Other	28 (12)	11 (21)	17 (9)	
Comorbidities				
BMI (mean ± SD)	29.39 ± 9.22	28.29 ± 8.40	29.68 ± 9.42	.355
COPD	30 (12)	7 (14)	23 (12)	.813
Asthma	18 (7)	0 (0)	18 (10)	.021
Heart failure	35 (15)	13 (25)	22 (12)	.015
Atrial fibrillation	24 (10)	6 (12)	18 (10)	.659
Liver cirrhosis	8 (3)	2 (4)	6 (3)	.806
Diabetes	118 (49)	30 (58)	88 (46)	.161
Chronic kidney disease	42 (17)	11 (21)	31 (16)	.414
Coronary artery disease	45 (19)	14 (27)	31 (16)	.106
Hypertension	180 (74)	42 (81)	138 (73)	.234
Obesity	97 (40)	21 (40)	76 (40)	1.000
Clinical and laboratory parameters on admission (mean ± SD)				
FiO_2% requirement	39 ± 28	80 (29-100)	21 (21-32)	<.0001
Ferritin, ng/mL	1888 ± 2836	1357 (634-2743)	660 (255-1671)	.004
D-dimer, ng/mL	3855 ± 6143	2200 (1410-3490)	1535 (800-2975)	.011
CRP, mg/dL	145 ± 116	186 (113-274)	100 (38-168)	<.0001
Procalcitonin, ng/mL	2.19 ± 7.07	0.87 (0.19-4.84)	0.16 (0.07-0.42)	<.0001
LDH, IU/L		510 (406-654)	360 (246-524)	<.0001
COVID-19 treatment				
Hydroxychloroquine	145 (60)	43 (83)	102 (54)	<.0001
Steroids	55 (23)	27 (52)	28 (15)	<.0001
Tocilizumab	21 (9)	8 (15)	13 (7)	.090
Clinical outcomes				
Need for CRRT/HD	24 (10)	14 (27)	10 (5)	<.0001
Need for vasopressors	49 (20)	36 (69)	13 (7)	<.0001
Need for mechanical ventilation	54 (22)	38 (73)	16 (8)	<.0001

Abbreviations: COVID-19, coronavirus disease 2019; CRRT, continuous renal replacement therapy; HD, hemodialysis; IQR, interquartile range; SD, standard deviation.

vasopressor use among hospitalized COVID-19 patients in an underserved minority population. Majority of these patients had hypertension (74%), almost half had diabetes mellitus (49%), and almost one fifth have obstructive lung disease (either COPD or asthma). The rates of comorbidities were significantly higher compared to the reported hospitalized patients in Wuhan, China,[5] and in Washington state.[6,7] In New York City, a report by Richardson et al[8] showed lower rates of hypertension (56.6%), diabetes (33.8%), and chronic respiratory disease (14.4%) compared to our population. Another study by Palaiodimos et al[9] from Bronx, New York reported higher rate of hypertension (76%) but lower rate diabetes (39.5%). Thus, our study samples are relatively sicker population compared to previous studies. This can be explained as our patient population have higher

proportion of African Americans (70%). They have genetic predisposition, socioeconomic factors, and pathophysiological differences with higher risk for various cardiometabolic risk factors such as hypertension, diabetes, and dyslipidemia that may explain the discrepancy in comorbidities.[10] As the morbidity and mortality report in Georgia on March 2020, to which 83.2% of their population were non-Hispanic black, showed that 67.5% had hypertension and such was more common among black vs nonblack patients (69.6% vs 54.0%; P = .047).[11]

Older age was established as a risk factor for inpatient death in COVID-19 patients. Multivariate regression analysis showed that age as a continuous variable is significantly associated with inpatient mortality (P < .001) with mean age higher amongst patient who died

TABLE 2 Multivariable logistic regression for factors associated with inpatient mortality

Characteristics	Odds ratio (95% CI)	P value
Age	1.056 (1.023-1.090)	.001
BMI	1.022 (0.977-1.069)	.349
Male	Referrant	
Female	0.729 (0.351-1.512)	.396
African American	Referrant	
Caucasian	2.899 (0.608-13.827)	.182
Hispanic	0.738 (0.193-2.828)	.658
Others	2.061 (0.760-5.591)	.155
COPD and asthma	0.471 (0.156-1.428)	.184
DM	1.450 (0.672-3.129)	.344
HTN	0.954 (0.375-2.426)	.922
HF	2.125 (0.835-5.410)	.114
cirrhosis	2.605 (0.389-17.428)	.324
CKD	0.806 (0.317-2.048)	.651

Abbreviations: BMI, body mass index; CI, confidence interval.

compared to those who survived (73 vs 64 years old; P < .0001). This finding was consistent with a retrospective cohort by Zhou et al,[5] to which 69 years old and older were significantly associated with death. In a logistic regression analysis by Palaiodimos et al,[9] age was significantly associated with in-hospital mortality (OR: 1.03; 95% CI: 1.00-1.07; P = .041).[9] Aging accompanies a decrease in functional cell-mediated immune response, increased production of IL-6, more prolonged inflammatory response and increased production of clotting factors (poor clearance of fibrin from circulation, increased levels of D-dimer) which leads to increase incidence and severity of

TABLE 3 Multivariate logistic regression of baseline inflammatory markers and association with inpatient mortality

Inflammatory markers	Odds ratio	P value
Fibrinogen	0.999 (0.996-1.002)	.551
D-dimer	1.000 (0.999-1.000)	.585
Ferritin	1.000 (0.999-1.000)	.063
CRP	1.008 (1.003-1.012)	.002
Procalcitonin	1.054 (0.989-1.123)	.104

response to infections, including the ones from intracellular organisms like viruses.[12]

Requirement of mechanical ventilation, vasopressor, and renal replacement therapy (CRRT/HD) was also associated significantly with inpatient death. These findings were similar to the report of the Intensive Care National Audit and Research Centre (ICNARC) May 2020. This described critically ill COVID-19 patients in England, Wales, and Northern Ireland National Health Services (NHS) and non-NHS critical care units to which more than half needed advance respiratory support (62%) and any renal replacement therapy (75%) died in critical care.[13] A retrospective study in Wuhan, China by Zhou et al[5] reported that 97% of patients who were intubated and 100% of those who received renal replacement therapy died during hospitalization.[5] In Washington, mortality was more than 50% in intubated patients.[6,7] In New York City, 88% who received mechanical ventilation and 96% who received kidney replacement therapy died as well.[8] There is limited information regarding association of vasopressors and inpatient mortality but the aforementioned ICNARC report showed 71% and 83.4% respective deaths in combined respiratory/cardiac and combined respiratory/renal/cardiac support respectively.[13] However, selection bias has to be considered in the association, as patients who received invasive ventilation,
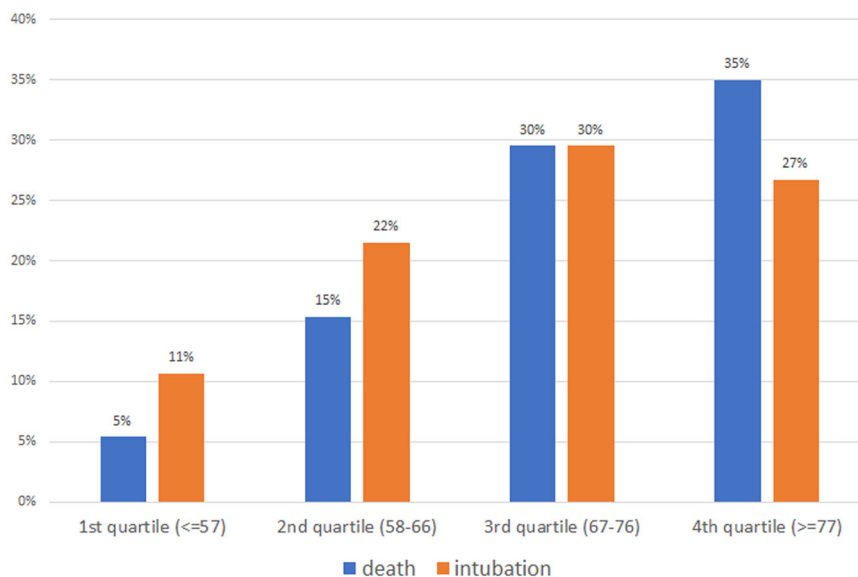
FIGURE 2 Stratification of inpatient death and need for intubation by quartiles of age

TABLE 4 Association of COVID-19 specific treatments with clinical outcomes comparing use and nonuse

Inpatient mortality (%)	Primary outcome Need for CRRT/ HD (%)	Secondary outcomes	Need for vasopressor (%)	Need for intubation (%)
Tocilizumab	38 vs 20	14 vs 10	43 vs 18	62 vs 19
	P = .0900	P = .4470	P = .0190	P < .0001
Steroids	49 vs 13	22 vs 12	49 vs 12	58 vs 12
	P < .0001	P = .0030	P < .0001	P < .0001
Hydroxychloroquine	30 vs 9	16 vs 1	28 vs 8	34 vs 5
	P < .0001	P < .0001	P < .0001	P < .0001

Abbreviations: COVID-19, coronavirus disease 2019; CRRT, continuous renal replacement therapy; HD, hemodialysis.

vasopressor, and renal replacement therapy were likely relatively sicker or these other surrogate outcomes merely reflected the degree of end-organ damage involved and hence risk of mortality.

Sex, BMI, and race were not established to have an association with poor clinical outcomes in our study. However, Palaiodimos et al[9] described male sex was independently associated with higher in-hospital mortality (OR: 3.35; 95% CI: 1.51-7.46; P = .003).[9] Studies also linked obesity to severe COVID-19[9,14,15] as it is associated decreased functional capacity and pulmonary compliance,[16] and chronic inflammatory state with increased proinflammatory cytokines further aggravating cytokine storm.[17] Discrepancy in observations can be attributed to significantly higher rates of obesity among females in our study group (P < .0001) (See Table S1). Metabolic comorbidities such as hypertension, coronary artery disease, and diabetes were also higher among females, however, were not statistically significant. In addition, the rate of obesity has no significant difference between patients who died and who survived as 40% of our population have BMI more than 30 kg/m^2. Although African American patients, who were 70% of our study population, tended to have higher rates of obesity, hypertension, and diabetes, there was no significant difference compared to other races (see Table S2). This is likely due to our unique underserved-inner city patient population. We have significant numbers of other racial minorities such as Hispanics and Asians. In fact, Caucasians were underrepresented in our sample population (see Table 1). Data have shown that deaths with COVID-19 are higher in racial minorities since other social-economic factors such as food and housing security and access to healthcare may play a role.[18] Hence, the lack of association of BMI, sex, and race with poor clinical outcomes can be explained by similar risk factor profile and similar socioeconomic profile of our patient population, who are generally sicker compared to study population in other published COVID-19 studies.

Patients in this study who received COVID-19 specific treatment (steroid, tocilizumab, and hydroxychloroquine) had poor clinical outcomes. There are conflicting observations regarding steroid use. In Wuhan, 48% of patients who received corticosteroids died (P = .0005).[5] The same observations were noted in a study by Bhatraju.[6] Glucocorticoid treatment for SARS-CoV 2003 and

MERS-CoV was also associated with worse clinical outcomes.[19,20] However, another nonrandomized study showed treatment with methylprednisolone decreased the risk of death among COVID-19 patients with ARDS.[21] Hydroxychloroquine, on the other hand, has failed to show accelerating viral clearance for in-hospital COVID-19 patients in multiple reports.[22,23] Use of hydroxychloroquine alone was associated with increased overall mortality compared with no hydroxychloroquine. Also, its use with or without azithromycin did not reduce the risk of mechanical ventilation.[24] For tocilizumab, there were only retrospective and single-arm observational studies available to which it has still insufficient clinical data to determine its harm or benefit.[25-27] The issue with all these treatment outcomes is the possibility of selection bias as the current guidelines only recommend the use of these "COVID-19 specific" treatments in the setting of a clinical trial which may prompt usage only in cases where the perceived disease morbidity or severity is high which can skew the mortality rates towards patients who are using these medications.

Inflammatory markers are currently used to monitor disease progression. Severe COVID-19 infection manifests as a cytokine storm syndrome. Patients in cytokine storm progress to cardiovascular collapse, multiple organ dysfunction, and eventually die rapidly.[28] In this study, only elevated baseline CRP was significantly associated with inpatient death. Mean CRP on admission among those who died was higher compared to those who survived were 186 vs 100 mg/dL (P < .0001). Another retrospective study showed not only D-dimer but including high-sensitivity cardiac troponin I, serum ferritin, lactate dehydrogenase, and IL-6 were elevated in nonsurvivors compared with survivors.[5] In addition, a study by Wu C et al[21] showed 85.6% patients with ARDS had increased CRP but association to inpatient death was not established. Nevertheless, the association of CRP in our study had a low odds ratio of 1.008 (95% CI: 1.003-1.012; P = .002) which makes it not that useful as associated factor or predictor. Clearly more studies perhaps with enough sample population to help establish thresholds values are needed to better elicit the roles of these inflammatory markers in terms of clinical outcomes or prognostication in COVID-19. In addition, it seems like signs of multiorgan failure such as need for intubation and

respiratory failure or need for CRRT/HD or acute renal failure seem to be more reliable signs of poor outcomes in patients with COVID-19 than the actual quantitative markers of inflammation.

5 | LIMITATIONS

This is a retrospective single-center experience study and was not powered to detect differences in outcomes for the treatments or medications. Some of the samples for COVID-19 were sent out to the local Department of Health during the early period of the COVID-19 pandemic this may add heterogeneity to the manner of testing. This study did not account for other potential confounding factors such as the use of home medications such as NSAIDs and ACE/ARBs. Another limitation was not accounting for time of initial symptoms to treatment or medications as this study points more to severity of presentation on hospital admission. There is also selection bias in terms of COVID-19 specific treatment as it seems like the sickest patients got more treatment and, hence having poorer outcomes. We did not do an in-depth analysis concerning the effects of these disease-specific treatments as it is already beyond the scope of this study. Continuous adaptation of COVID-19 specific treatments was also based on existing evidences that are made available. This issue remains dynamic so changes in prescribing patterns for these medications may need to be taken into account. Other confounding clinical factors such as concomitant secondary bacterial superinfections and acute flare-ups of existing co-morbidities may also play a role in influencing clinical outcomes which were not accounted for in our analysis.

6 | CONCLUSION

Majority of inpatients COVID-19 have hypertension and diabetes mellitus. Age was found as an independent risk factor for inpatient mortality as it increases significantly after 58 years old. Requirement of mechanical ventilation, vasopressor, and renal replacement therapy (CRRT/HD) was also associated significantly with inpatient mortality. Amongst inflammatory markers, only elevated baseline CRP was significantly associated with inpatient death however its use in prognostic association may be limited.

CONFLICT OF INTERESTS
The authors declare that there are no conflict of interests.

AUTHOR CONTRIBUTION
All the authors were involved in conceptualization and planning of the manuscript. GS, FG, EP, RDJ III, RB, JP, and JA did data collection. KBL performed data analysis. GS, KBL, SB, GP-A, and JR were involved in the manuscript writing and editing revisions. ZA, GP-A, and JR supervised the entire team in this study.

ORCID
Grace Salacup http://orcid.org/0000-0002-0003-2040

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SUPPORTING INFORMATION

Additional supporting information may be found online in the Supporting Information section.