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Severe obesity, increasing age and male sex are independently associated with worse in-hospital outcomes, and higher in-hospital mortality, in a cohort of patients with COVID-19 in the Bronx, New York

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ABSTRACT

Background & aims: New York is the current epicenter of Coronavirus disease 2019 (COVID-19) pandemic. The underrepresented minorities, where the prevalence of obesity is higher, appear to be affected disproportionately. Our objectives were to assess the characteristics and early outcomes of patients hospitalized with COVID-19 in the Bronx and investigate whether obesity is associated with worse outcomes independently from age, gender and other comorbidities.

Methods: This retrospective study included the first 200 patients admitted to a tertiary medical center with COVID-19. The electronic medical records were reviewed at least three weeks after admission. The primary endpoint was in-hospital mortality.

Results: 200 patients were included (female sex: 102, African American: 102). The median BMI was 30 kg/m^2. The median age was 64 years. Hypertension (76%), hyperlipidemia (46.2%), and diabetes (39.5%) were the three most common comorbidities. Fever (86%), cough (76.5%), and dyspnea (68%) were the three most common symptoms. 24% died during hospitalization (BMI < 25 kg/m^2: 31.6%, BMI 25–34 kg/m^2: 17.2%, BMI ≥ 35 kg/m^2: 34.8%, $p = 0.03$). Increasing age (analyzed in quartiles), male sex, BMI ≥ 35 kg/m^2 (reference: BMI 25–34 kg/m^2), heart failure, CAD, and CKD or ESRD were found to have a significant univariate association with mortality. The multivariate analysis demonstrated that BMI ≥ 35 kg/m^2 (reference: BMI 25–34 kg/m^2, OR: 3.78; 95% CI: 1.45–9.83; $p = 0.006$), male sex (OR: 2.74; 95% CI: 1.25–5.98; $p = 0.011$) and increasing age (analyzed in quartiles, OR: 1.73; 95% CI: 1.13–2.63; $p = 0.011$) were independently associated with higher in-hospital mortality. Similarly, age, male sex, BMI ≥ 35 kg/m^2 and current or prior smoking were significant predictors for increasing oxygenation requirements in the multivariate analysis, while male sex, age and BMI ≥ 35 kg/m^2 were significant predictors in the multivariate analysis for the outcome of intubation.

Conclusions: In this cohort of hospitalized patients with COVID-19 in a minority-predominant population, severe obesity, increasing age, and male sex were independently associated with higher in-hospital mortality and in general worse in-hospital outcomes.

1. Introduction

Coronavirus disease 2019 (COVID-19), which is caused by severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2), has evolved to a global pandemic with more than two million confirmed cases and about 200 thousand deaths so far [1]. The first cases in the United States (U.S.) were reported on January 19th, 2020 in the Washington state [2]. Since then, about one million confirmed cases and sixty thousand deaths have been reported [3]. New York City (NYC) is the current epicenter of the pandemic with about 160 thousand confirmed cases and more than twelve thousand deaths to date [4]. Early reports from Asia and Europe have identified older age, male sex, and chronic medical conditions, such as diabetes, hypertension, obesity, coronary artery disease, and heart failure, as risk factors associated with worse

Abbreviations: COVID-19, Coronavirus disease 2019; SARS-CoV-2, acute respiratory syndrome coronavirus 2; BMI, body mass index; OR, odds ratio; CI, confidence interval; EMR, electronic medical record; SNF, skilled nursing facility.

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outcomes [5–7]. However, little is known about the risk factors and the characteristics of the disease in the United States population and particularly in underrepresented minorities, who appear to be affected disproportionally by COVID-19 [4,7]. The age-adjusted death rate per 100,000 people in NYC is more than double for African Americans compared to Whites (127.1 vs. 63.5) [4]. The higher prevalence of medical conditions that are considered risk factors for severe COVID-19 among African Americans and the higher risk for exposure to SARS-CoV-2 due to living and working conditions seem to be plausible explanations for the observed disproportionate differences in outcomes [7]. The Bronx, which is the most diverse area in the United States as per the 2010 U.S. Census, ranks last among all 62 counties of New York state in health outcomes, quality of life and important health and socioeconomic factors according to County Health Rankings and Roadmaps [8]. In addition, the Bronx has the highest obesity rates among all NYC boroughs and stands remarkably higher than the national average [9,10].

Our primary objective with this analysis was to investigate whether obesity is associated with worse in-hospital outcomes. Our secondary objective was to assess and present the clinical characteristics and early outcomes of the first 200 patients, who were diagnosed with COVID-19 and admitted to a large tertiary academic center.

2. Materials and methods

2.1. Study design and patient population

This retrospective cohort study was conducted at the Montefiore Medical Center, a tertiary academic institution in the Bronx, New York. The first 200 patients who presented to the emergency room (ER) and were admitted to the inpatient medicine service or the intensive care unit (ICU) with laboratory-confirmed COVID-19 were included. We excluded patients who met one of the following exclusion criteria: i) discharge home directly from the ER, ii) transfer to our center after having received care in other institutions and iii) admission for non-COVID-19 related reasons or non-medical reasons (e.g. patients admitted because of a fracture, clinically stable patients residing in group homes unable to self-isolate). The 200 included patients were followed for three weeks after their admission to the hospital (admission of 1st patient: March 9, 2020; admission of the 200th patient: March 22, 2020; completion of 3-week follow-up: April 12, 2020).

The study was approved by the institutional review board (IRB) of the Albert Einstein College of Medicine with a waiver of informed consent (IRB number 2020-11296).

2.2. Data extraction

Two researchers (LP, WL) reviewed all 200 electronic medical records (EMR) independently in a pre-defined data extraction sheet which was created for the purpose of this study. Discrepancies were resolved with discussion.

The documentation of the index admission from emergency medicine providers, inpatient providers, consultants, nurses, therapists, and social workers, the laboratory, and imaging data were reviewed. Post-discharge notes (e.g., tele-medicine follow-up visits, nursing outreach) were also reviewed when available. Documentation from past visits and the search engine of the EMR were also utilized.

The extracted data included baseline demographic information [age, gender, race/ethnicity, residence status (community or skilled nursing facility/SNF), and zip code], clinical characteristics [body mass index (BMI), history of smoking, alcohol, intravenous drug use, hypertension, diabetes, hyperlipidemia, coronary artery disease (CAD), heart failure, cerebrovascular disease, chronic obstructive pulmonary disease (COPD), asthma, active malignancy, chronic kidney disease (CKD) or end-stage renal disease (ESRD), liver cirrhosis, and human immunodeficiency virus infection (HIV) or acquired immunodeficiency syndrome (AIDS)], pertinent home medications (immunosuppressive agents, ace-inhibitors, angiotensin II receptor blockers), symptomatology since disease onset and on presentation (fever, headache, malaise, myalgia, rhinorrhea, nasal congestion, sore throat, chest pain, dyspnea, cough, sputum production, nausea/vomiting, diarrhea), vital signs on presentation (oxygen saturation on room air, heart rate, presence of fever), level of oxygen requirement in the ER, laboratory data on the first hospital day [white cell count, lymphocyte count, hemoglobin, platelet count, creatinine, aspartate transaminase (AST), alanine transaminase (ALT), troponin T, creatinine kinase (CPK), lactate dehydrogenase (LDH), Ferritin, d-dimers, C-reactive protein (CRP), procalcitonin, and hemoglobin A1c for diabetics], initial imaging findings (chest X-ray and/or chest computed tomography), oxygen requirements during hospital stay, acute respiratory distress syndrome (ARDS), intubation, number of days from presentation to intubation, ICU admission, acute kidney injury (AKI) or need for initiation of renal replacement therapy, length of stay, death, and hospital discharge.

The data were processed and analyzed without any personal identifiers to maintain patient confidentiality as per Health Insurance Portability and Accountability Act (HIPAA).

2.3. Outcomes and statistical analysis

Patients were classified in three groups based on the BMI: BMI < 25 kg/m^2, BMI 25–34 kg/m^2, and BMI ≥ 35 kg/m^2 as per the most recent BMI assessment prior to or during the index admission. Severe obesity was defined as BMI ≥ 35 kg/m^2. Patients were also classified in four quartiles based on age: ≤50, 51–64, 65–73, and ≥74 years old. The primary endpoint was in-hospital mortality. Secondary endpoints included: increasing oxygen requirement during hospital stay and intubation. Deceased patients were excluded from the length of stay analysis. Continuous data are presented as median with interquartile range (IQR) and categorical data as absolute and relative frequencies. The ANOVA test was used to compare the continuous variables, while chi-square was used for discrete variables. Interaction analyses were performed as needed. A logistic regression model was used to identify baseline variables associated with in-hospital mortality, intubation and increasing oxygen requirements. BMI 25–34 kg/m^2 was used as a reference in order to perform dichotomous comparisons with patients with severe obesity (BMI ≥ 35 kg/m^2). In order to build a multivariate model, we used a forward stepwise approach with the following method for each one of the studied outcomes; model 1: BMI and age, model 2: all the variables with significant univariate associations (p value ≤ 0.05), and model 3: the variables of model 2 in addition to clinically significant variables which did not show a significant univariate association. Additional logistic regression analyses with BMI and age handled as continuous variables were performed. Results of logistic regression are given as the odds ratio (OR) with the 95% confidence interval (CI). The threshold of statistical significance was $p \leq 0.05$. All analyses were performed using STATA software (version 14·1; STATA Corporation, College Station, TX, USA).

3. Results

In total, 200 patients admitted with COVID-19 were included in this analysis (female sex = 102, BMI < 25 kg/m^2 = 38, BMI 25–34 kg/m^2 = 116, and BMI ≥ 35 kg/m^2 = 46). The median BMI was 30 (IQR 26–35) kg/m^2. Most of our patients were either of African American race (51%) or of Hispanic ethnicity (34.5%). 23.5% were SNF residents. The median age of the whole cohort was 64 (50–73.5) years, with significant differences among the three groups [BMI < 25 kg/m^2: 73 (64–80) vs. BMI 25–34 kg/m^2: 63 (48.5–71) vs. BMI ≥ 35 kg/m^2: 57.5 (45–67), $p < 0.001$]. 32.5% of our cohort was active or past smokers. Hypertension, hyperlipidemia and coronary artery disease were prevalent in 76%, 46.2% and 16.5% of our patients, respectively. 17% had a history of

heart failure while 27.5% had a history of asthma or COPD. 29% had a history of chronic kidney disease or ESRD. Diabetes was prevalent in 39.5% of our patients. The detailed baseline demographic and clinical characteristics are presented in Table 1.

Fever (86%), cough (76.5%), dyspnea (68%) and malaise (58%) were the four most common symptoms. The median SO_2 on the first hospital day was 95% (IQR 89–97) without significant differences among groups. Symptoms and signs are presented in Table 2. All 200 patients received chest X-ray on presentation, with 55.5% of them having bilateral infiltrates and 27% having only unilateral findings. The laboratory and radiologic findings are presented in Table 3.

In total, 24% of our cohort died during hospitalization, with higher rates among individuals with severe obesity (BMI < 25 kg/m^2: 31.6%, BMI 25–34 kg/m^2: 17.2%, BMI ≥ 35 kg/m^2: 34.8%, $p = 0.030$). Similarly, patients with severe obesity were more likely to undergo intubation (BMI < 25 kg/m^2: 18.4%, BMI 25–34 kg/m^2: 16.4%, BMI ≥ 35 kg/m^2: 34.8%, $p = 0.032$). In total, 45% of our patients had increasing oxygen requirements during hospital stay without significant differences among BMI groups. Twenty-two percent developed ARDS and 16% spent at least one night in the ICU. In-hospital outcomes are presented in Table 4 and in Fig. 1.

3.1. Logistic regression analyses

3.1.1. In-hospital mortality

The univariate associations with in-hospital mortality were examined for all the baseline demographic and clinical characteristics. Increasing age (analyzed in quartiles), male sex, BMI ≥ 35 kg/m^2 (reference: BMI 25–34 kg/m^2), heart failure, CAD, and CKD or ESRD were found to have a significant univariate association (Table 5). The following variables were not shown to be statistically significant in the univariate associations: hypertension, hyperlipidemia, obstructive sleep apnea, diabetes, and smoking (Table 5). In the multivariable analysis (model 3), male sex (OR: 2.74; 95% CI: 1.25–5.98; $p = 0.011$), increasing age (OR: 1.73; 95% CI: 1.13–2.63; $p = 0.011$), and BMI ≥ 35 kg/m^2 (OR: 3.78; 95% CI: 1.45–9.83; $p = 0.006$) were found to have significant associations.

Table 1
Baseline demographic and clinical characteristics.

Characteristic	All patients	BMI group				Age group				
	N = 200	BMI < 25 (N = 38)	BMI 25–34 (N = 116)	BMI ≥ 35 (N = 46)	*p*-Value	≤50 (N = 51)	51–64 (N = 53)	65–73 (N = 46)	≥74 (N = 50)	*p*-Value
		(a)	(b)	(c)		(a)	(b)	(c)	(d)	
Male sex - no. (%)	98 (49.0)	21 (55)	58 (50)	19 (41)	0.420	29 (56.9)	20 (37.7)	29 (63.0)	20 (40.0)	0.027
Age - years										
Median (IQR)	64 (50–73.5)	73 (64–80)[bc]	63 (48.5–71)[a]	57.5 (45–67)[a]	<0.001	42 (35–46)	58 (56–62)	68 (66–70)	78 (75–84)	<0.001
Distribution - no. (%)										
≤50	51 (25.5)	4 (10.5)[bc]	32 (27.6)[a]	15 (32.6)[a]	<0.001	51 (100)	0 (0.0)	0 (0.0)	0 (0.0)	<0.001
51–64	53 (26.5)	6 (15.8)[bc]	30 (25.9)[a]	17 (7.0)[a]		0 (0.0)	53 (100)	0 (0.0)	0 (0.0)	
65–73	46 (23.0)	9 (23.7)[bc]	28 (24.1)[a]	9 (19.6)[a]		0 (0.0)	0 (0.0)	46 (100)	0 (0.0)	
≥74	50 (25.0)	19 (50.0)[bc]	26 (22.4)[a]	5 (10.9)[a]		0 (0.0)	0 (0.0)	0 (0.0)	50 (0.0)	
Residence status - no. (%)										
SNF resident	47 (23.5)	13 (34.2)	25 (21.6)	9 (19.6)	0.216	4 (7.8)[d]	11 (20.8)	12 (26.1)	20 (40.0)[a]	0.002
Community-based	153 (76.5)	25 (65.8)	91 (78.5)	37 (80.4)		47 (92.2)[d]	42 (79.2)	34 (73.9)	30 (60.0)[a]	
Race/ethnicity - no. (%)										
African American	102 (51.0)	21 (55.3)	55 (47.4)	26 (56.5)	0.142	18 (35.3)[bd]	29 (54.7)[a]	22 (47.8)	33 (66.0)[a]	0.004
Hispanic/Latino	69 (34.5)	8 (21.1)	47 (40.5)	14 (30.4)		39 (56.9)[bd]	15 (28.3)[a]	16 (34.8)	9 (18.0)[a]	
Other	29 (14.5)	9 (23.7)	14 (12.1)	6 (13.0)		4 (7.8)[bd]	9 (20.0)[a]	8 (17.4)	8 (16.0)[a]	
BMI - kg/m^2										
Median (IQR)	30 (26–35)	22 (20.7–24)[bc]	29 (27–31)[ac]	41 (37–46)[ab]	<0.001	31 (27–38)[d]	32 (29–37)[d]	29 (25–32)	26 (23−30)[ab]	<0.001
Smoking - no./total no. (%)										
Never smoked	135 (67.5)	20 (52.6)	80 (69.0)	35 (76.1)	0.064	41 (80.4)	32 (60.4)	26 (56.5)	36 (72.0)	0.044
Former or current smoker	65 (32.5)	18 (47.4)	36 (31.0)	11 (23.9)		10 (19.6)	21 (39.6)	20 (43.5)	14 (28.0)	
Coexisting disorder - no. (%)										
Any	182 (91.0)	35 (92.1)	106 (91.4)	41 (89.1)	0.872	37 (72.6)[bcd]	51 96.2)[a]	45 (97.8)[a]	49 (98.0)[a]	<0.001
Hypertension	152 (76.0)	30 (79.0)	89 (76.7)	33 (71.7)	0.715	25 (49.0)[bcd]	41 (77.4)[a]	40 (87.0)[a]	46 (92.0)[a]	<0.001
Diabetes	79 (39.5)	14 (36.8)	41 (35.3)	24 (52.2)	0.133	14 (27.5)	21 (39.6)	24 (52.2)	20 (40.0)	0.102
Hyperlipidemia	92 (46.2)	16 (43.2)	55 (47.4)	21 (45.7)	0.903	15 (29.4)[c]	23 (43.4)	27 (60.0)[a]	27 (50.0)	0.014
Coronary artery disease	33 (16.5)	8 (21.1)	19 (16.4)	6 (13.0)	0.615	3 (5.9)[d]	10 (18.9)	7 (15.2)	13 (26.0)[a]	0.052
Cerebrovascular disease	22 (11.0)	9 (23.7)[bc]	11 (9.5)[a]	2 (4.4)[a]	0.014	1 (2.0)[d]	3 (5.7)[d]	6 (13.0)	12 (24.0)[ab]	0.002
Heart failure	34 (17.0)	14 (36.8)[bc]	12 (10.3)[a]	8 (17.4)[a]	0.001	4 (7.8)[d]	8 (15.1)	7 (15.2)	15 (30.0)[a]	0.026
Asthma	27 (13.5)	5 (13.2)	18 (15.5)	4 (8.7)	0.518	10 (19.6)	4 (7.6)	9 (19.6)	4 (8.0)	0.112
COPD	28 (14.0)	7 (18.4)	14 (12.1)	7 (15.2)	0.597	0 (0.0)[d]	10 (18.9)	7 (15.2)[d]	11 (22.0)[ac]	0.007
Chronic renal disease	58 (29.0)	16 (42.1)	28 (24.1)	14 (30.4)	0.103	7 (13.7)[d]	15 (28.3)	16 (34.8)	20 (40.0)[a]	0.024
CKD III–V	41 (20.5)	9 (23.7)	20 (17.2)	12 (26.1)		3 (5.88)	9 (16.7)	13 (28.3)	16 (32.0)	0.033
ESRD	17 (8.5)	7 (18.4)	8 (6.9)	2 (4.4)		4 (7.8)	6 (11.3)	3 (6.5)	4 (8.0)	
Active malignancy	11 (5.5)	1 (2.6)	6 (5.2)	4 (8.7)	0.465	0 (0.0)[d]	3 (5.7)	2 (4.4)	6 (12.0)[a]	0.067
Liver cirrhosis	2 (1.0)	0 (0.0)	0 (0.0)[c]	2 (4.4)[b]	0.034	0 (0.0)	1 (1.89)	1 (2.2)	0 (0.0)	0.556
HIV/AIDS	5 (2.5)	1 (2.6)	3 (2.6)	1 (2.2)	0.987	1 (2.0)	3 (5.7)	1 (2.2)	0 (0.0)	0.316
ACEi or ARB use - no. (%)										
ACEi	36 (18.0)	8 (21.1)	20 (17.2)	8 (17.4)	0.862	5 (9.8)	12 (22.6)	9 (19.6)	10 (20.0)	0.347
ARB	25 (12.6)	5 (13.2)	14 (12.1)	6 (13.3)	0.969	5 (9.8)	4 (7.7)	6 (13.0)	10 (20.0)	0.261
None	138 (69.0)	13 (34.2)	34 (29.1)	15 (32.6)	0.821	41 (80.4)	36 (67.9)	31 (67.4)	30 (60.0)	0.167
Immunosuppressive tx - no. (%)	17 (8.5)	3 (7.9)	13 (11.2)	1 (2.2)	0.176	3 (5.9)	5 (9.4)	5 (10.9)	4 (8.0)	0.836

Note: *p*-Values refer to Chi-square test/ANOVA and the letters denote the columns with which a statistically significant pairwise comparison exists (Bonferroni's method).
Abbreviations and symbols: BMI = body mass index, IQR = interquartile range, no. = number, SNF = skilled nursing facility, kg = kilogram, m = meter, CKD = chronic kidney disease, ESRD = end-stage renal disease, HIV = human immunodeficiency virus, AIDS = acquired immunodeficiency syndrome, ACEi = angiotensin-converting enzyme inhibitor, ARB = angiotensin receptor blocker, tx = treatment.

Table 2
Symptoms and signs on presentation.

Characteristic	All patients	BMI group				Age group				
	N = 200	BMI < 25 (N = 38) (a)	BMI 25–34 (N = 116) (b)	BMI ≥ 35 (N = 46) (c)	*p*-Value	≤50 (N = 51) (a)	51–64 (N = 53) (b)	65–73 (N = 46) (c)	≥74 (N = 50) (d)	*p*-Value
Symptoms - no. (%)										
Fever	172 (86.0)	29 (76.3)	102 (87.9)	41 (89.1)	0.158	48 (94.1)[d]	47 (88.7)	40 (87.0)	37 (74.0)[a]	0.028
Cough	153 (76.5)	29 (76.3)	88 (75.9)	36 (78.3)	0.948	42 (82.4)	38 (71.7)	37 (80.4)	36 (72.0)	0.456
Dyspnea	136 (68.0)	23 (60.5)	76 (65.5)	37 (80.4)	0.102	37 (72.6)	39 (73.6)	30 (65.2)	30 (60.0)	0.411
Malaise	116 (58.0)	22 (57.9)	70 (60.3)	24 (52.2)	0.637	26 (51.0)	34 (64.2)	29 (63.0)	27 (54.0)	0.446
Diarrhea	66 (33.0)	8 (21.0)[c]	35 (30.2)[c]	23 (50.0)[ab]	0.012	23 (45.1)	21 (39.6)	10 (21.7)	12 (24.0)	0.031
Myalgia	61 (30.5)	9 (23.7)	37 (31.9)	15 (32.6)	0.596	22 (43.1)	17 (32.1)	13 (28.3)	9 (18.0)	0.053
Sputum production	46 (23.0)	8 (21.5)	26 (22.4)	12 (26.1)	0.839	12 (23.5)	15 (28.3)	11 (23.9)	8 (16.0)	0.521
Headache	40 (20.0)	4 (10.53)	26 (22.4)	10 (21.7)	0.267	12 (23.5)	17 (32.1)[d]	9 (19.6)	2 (4.0)[b]	0.004
Nasal congestion or rhinorrhea	37 (18.5)	7 (18.4)	22 (19.0)	8 (17.4)	0.973	14 (27.5)	11 (20.8)	7 (15.2)	5 (10.0)	0.132
Nausea or vomiting	35 (17.5)	4 (10.5)	22 (19.0)	9 (19.6)	0.452	11 (21.6)	10 (18.9)	5 (10.9)	9 (18.0)	0.559
Sore throat	20 (10.0)	4 (10.3)	12 (10.3)	4 (8.7)	0.945	6 (11.8)	7 (13.2)	3 (6.5)	4 (8.0)	0.654
Recorded fever on day 1 - no. (%)	126 (63.0)	22 (57.9)	75 (64.7)	29 (63.0)	0.755	34 (66.7)	34 (64.2)	31 (67.4)	27 (54.0)	0.486
Minimum SO_2 on room air on day 1										
Median (IQR) - %	95 (89–97)	95 (87–97)	95 (93–97)	93 (88–96)	0.346	96 (94–97)	94 (89.5–97)	94 (87–97)	95 (88–96)	0.077
Distribution - no. (%)										
≤80%	14 (7.0)	1 (2.6)	8 (6.9)	5 (10.9)	0.003	1 (2.0)	5 (9.4)	6 (13.0)	2 (4.0)	0.407
81–87%	25 (12.5)	10 (26.3)	10 (8.6)	5 (10.9)		4 (7.8)	6 (11.3)	7 (15.2)	8 (16.0)	
88–91%	20 (10.0)	4 (10.5)	6 (5.2)	10 (21.7)		4 (7.84)	6 (11.3)	2 (4.4)	8 (16.0)	
92–96%	86 (43.0)	11 (29.0)	58 (50.0)	17 (37.0)		25 (49.0)	22 (41.5)	18 (39.1)	21 (42.0)	
≥97%	55 (27.5)	12 (31.6)	34 (29.3)	9 (19.6)		17 (33.3)	14 (26.4)	13 (28.3)	11 (22.0)	

Note: *p*-Values refer to Chi-square test/ANOVA and the letters denote the columns with which a statistically significant pairwise comparison exists (Bonferroni's method).
Abbreviations: BMI = body mass index, IQR = interquartile range, no. = number, SO_2 = oxygen saturation.

3.1.2. Increasing oxygen requirements

Male sex, current or former smoking and BMI ≥ 35 kg/m^2 (reference: BMI 25–34 kg/m^2) were found to have a significant univariate association with increasing oxygen requirements (Table 6). In the multivariate analysis (model 3), male sex (OR: 2.77; 95% CI: 1.48–5.19; $p = 0.001$), increasing age analyzed in quartiles (OR: 1.38; 95% CI: 1.01–1.89; $p = 0.042$), BMI ≥ 35 kg/m^2 (OR: 3.09; 95% CI: 1.43–6.69; $p = 0.004$), and current or prior smoking (OR: 2.10; 95% CI: 1.07–4.10; $p = 0.031$) were significant predictors (Table 6).

3.1.3. Intubation

Male sex and BMI ≥ 35 kg/m^2 (reference: BMI 25–34.9 kg/m^2) were found to have significant univariate associations with intubation (Table 7). In the multivariate analysis (model 3), male sex (OR: 3.35; 95% CI: 1.51–7.46, $p = 0.003$), increasing age analyzed in quartiles (OR: 1.50; 95% CI: 1.05–2.12; $p = 0.025$), and BMI ≥ 35 kg/m^2 (OR: 3.87; 95% CI: 1.47–10.18; $p = 0.006$) were significant predictors (Table 7).

3.1.4. Additional analysis with BMI and age as continuous variables

We performed additional logistic regression analyses for all three outcomes where BMI and age were handled as continuous variables (Table 8). BMI as a continuous variable had only a limited association (OR: 1.05; 95% CI: 1.00–1.10; $p = 0.071$) with mortality after adjustment for age and sex (Table 8 panel A). However, BMI had a significant association with increasing oxygenation requirements (OR: 1.05; 95% CI: 1.01–1.09; $p = 0.017$) after adjusting for age, sex, and all the covariates in the model 4 (OR: 1.05; 95% CI: 1.01–1.10; $p = 0.014$) (Table 8 panel B). BMI was significantly associated with intubation (OR: 1.05; 95% CI: 1.01–1.10; $p = 0.026$) after adjusting for age and sex (Table 8 panel C).

Age as a continuous variable was significantly associated with mortality (OR: 1.03; 95% CI: 1.00–1.07; $p = 0.041$) (Table 8 panel A), and increasing oxygen requirements (OR: 1.02; 95% CI: 1.00–1.05; $p = 0.044$) (Table 8 panel B), but not with intubation, although a trend was noticed (OR: 1.03; 95% CI: 1.00–1.05; $p = 0.071$) (Table 8 panel C) in the multivariate analysis (model 4).

3.2. Interaction analysis

Given the significant associations that we noticed for male sex, age and BMI ≥ 35 kg/m^2 with the outcomes that we examined, we performed an interaction analysis for this set of variables. Two different interactions were tested; sex with BMI and age with BMI. Both of them were not significant.

4. Discussion

Our study described the baseline characteristics, clinical features, and early outcomes of the first 200 patients who were hospitalized due to COVID-19 in an institution which mainly serves African American and Hispanic population. This is the first study that has performed joint evaluation of age, gender, obesity and multiple comorbidities that have previously been linked with adverse outcomes. The main findings can be summarized as following: 1) the in-hospital mortality was 24% with only 3% patients still hospitalized on the 21-day follow-up 2) severe obesity (BMI ≥ 35 kg/m^2), increasing age, and male sex are independently associated with mortality and need for intubation 3) severe obesity (BMI ≥ 35 kg/m^2), increasing age, male sex, and smoking were also independently associated with increasing oxygen requirements during hospitalization.

Older age and male sex have already been described as risks factor for severe disease and death in patients with COVID-19 [5,11–16], although large outcome studies are needed to assess the latter. The most interesting finding of our analysis is that severe obesity is a significant factor for severe respiratory disease and death in hospitalized patients with COVID-19. It should be pointed out that this association remained significant even after adjusting for several clinical entities, such as diabetes, coronary artery disease, heart failure, COPD, CKD or ESRD, and smoking, which indicates that obesity may predispose to negative outcomes independently. The higher mortality rates in the

Table 3
Laboratory and imaging findings on presentation.

Characteristic	All patients	BMI group				Age group				
	N = 200	BMI < 25 (N = 38)	BMI 25–34 (N = 116)	BMI ≥ 35 (N = 46)	*p*-Value	≤50 (N = 51)	51–64 (N = 53)	65–73 (N = 46)	≥74 (N = 50)	*p*-Value
		(a)	(b)	(c)		(a)	(b)	(c)	(d)	
White-cell count										
Median (IQR) - per 10^3/μL	6.3 (4.7–7.8)	6.3 (4–8.3)	6.1 (4.7–7.6)	6.8 (5.3–8)	0.075	5.7 (4.4–7.5)	6.8 (5.2–8.8)	6.2 (4.7–8.3)	6.3 (5–7.4)	0.622
Distribution										
≥10,000/μL	23 (11.5)	5 (13.2)	13 (11.2)	5 (10.9)	0.937	4 (7.8)	10 (18.9)	5 (10.9)	4 (8.0)	0.249
≤4000/μL	35 (17.5)	10 (26.3)	20 (17.2)	5 (10.9)	0.178	9 (17.7)	8 (15.1)	7 (15.2)	11 (22.0)	0.782
Lymphocyte count										
Median (IQR) - per 10^3/μL	0.9 (0.7–1.3)	0.8 (0.6–1.1)	0.9 (0.6–1.3)	1.1 (0.8–1.5)	0.467	0.9 (0.8–1.3)	1 (0.7–1.3)	0.9 (0.6–1.4)	0.9 (0.6–1.3)	0.923
≤1000/μL	123 (61.5)	28 (73.7)[c]	73 (62.9)	22 (47.8)[a]	0.047	33 (64.7)	28 (52.8)	30 (65.2)	32 (64.0)	0.512
Hemoglobin - median (IQR) - g/dL	12.7 (11.1–14.2)	12 (10.3–13.8)	13 (11.5–14.3)	13 (10.8–14.1)	0.667	14 (12.1–15.3)[d]	12.7 (11–13.9)	12.9 (11.4–14.1)	12.2 (11–13.1)[a]	0.029
Platelets - median (IQR) - per 10^3/μL	194 (149–240)	178 (134–271)	194 (154–240)	208 (160–231)	0.044	197 (167–231)	200 (151–254)	185 (144–232)	177 (132–240)	0.669
Creatinine - median (IQR) - mg/dL	1 (0.8–1.7)	1.15 (0.8–2.4)	1 (0.8–1.5)	1.1 (0.8–1.7)	0.082	0.9 (0.7–1.2)	0.9 (0.8–1.7)	1.1 (0.8–1.9)	1.2 (0.9–1.8)	0.735
AST ≥ 50 U/L	72 (36.0)	15 (39.5)	40 (34.5)	17 (37.0)	0.847	18 (35.3)	23 (43.4)	12 (26.1)	19 (38.0)	0.345
ALT ≥ 50 U/L	36 (18.0)	6 (15.8)	22 (19.0)	8 (17.4)	0.900	11 (21.6)	14 (26.4)	6 (13.0)	5 (10.0)	0.116
CK ≥ 200 U/L	104 (52.0)	18 (47.4)	56 (48.3)	30 (65.2)	0.123	21 (41.2)	31 (58.5)	25 (54.4)	27 (54.0)	0.325
Troponin T ≥ 0.1 ng/mL	56 (28.0)	14 (36.8)	32 (27.6)	10 (21.7)	0.305	17 (33.3)	16 (30.2)	10 (21.7)	13 (26.0)	0.606
LDH ≥ 240 U/L	172 (86.0)	33 (86.8)	97 (83.6)	42 (91.3)	0.440	47 (92.2)	46 (86.8)	38 (82.6)	41 (82.0)	0.434
C-reactive protein										
Median (IQR) - mg/dL	8.35 (4.4–15)	11.6 (5.5–24.6)	7.75 (4.35–13.9)	9.45 (4.5–14.95)	0.025	8.1 (4.4–14.5)	6.5 (4.4–12.2)	11.2 (4.6–18.8)	8 (3.5–15.6)	0.362
≥5 mg/dL	81/122 (66.4)	17/22 (77.3)	48/76 (63.2)	16/24 (66.7)	0.467	23/34 (67.6)	21/33 (63.6)	18/25 (72.0)	19/30 (63.3)	0.893
≥10 mg/dL	55/122 (45.1)	12/22 (54.6)	31/76 (40.8)	12/24 (50.0)	0.450	16/34 (47.1)	11/33 (33.3)	14/25 (56.0)	14/30 (46.7)	0.372
≥15 mg/dL	31/122 (25.4)	9/22 (40.9)	16/76 (21.1)	6/24 (25.0)	0.169	8/34 (23.5)	6/33 (18.2)	8/33 (32.0)	9/33 (30.0)	0.598
D-dimer ≥ 1 μg/mL	38/64 (59.4)	11/13 (84.6)	19/37 (51.4)	8/14 (57.1)	0.108	9/21 (42.3)	11/16 (68.75)	8/13 (61.6)	10/14 (71.4)	0.281
D-dimer ≥ 3 μg/mL	13/64 (20.3)	2/13 (15.4)	10/37 (27.0)	1/14 (7.1)	0.256	2/21 (9.5)	5/16 (31.3)	2/13 (15.4)	4/14 (28.6)	0.324
Ferritin ≥ 500 ng/mL	14/22 (63.6)	3/3 (100.0)[c]	10/12 (83.3)[c]	1/7 (14.3)[ab]	0.004	4/5 (80.0)	3/7 (42.9)	6/8 (75.0)	1/2 (50.0)	0.477
Ferritin > 270 ng/mL	20/22 (90.9)	3/3 (100.0)	12/12 (100.0)	5/7 (71.4)	0.095	4/5 (80.0)	6/7 (85.7)	8/8 (100)	2/2 (100)	0.583
Procalcitonin										
Median (IQR) - ng/mL	0.1 (0.1–0.4)	0.1 (0.1–0.8)	0.1 (0.1–0.3)	0.1 (0.1–0.6)	0.544	0.1 (0.1–0.6)	0.1 (0.1–0.6)	0.2 (0.1–0.3)	0.1 (0.1–0.3)	0.346
>0.1 ng/mL	42/98 (42.9)	9/19 (47.4)	23/58 (40.0)	10/21 (47.6)	0.743	6/17 (35.3)	13/33 (39.4)	13/26 (50.0)	10/22 (45.5)	0.762
≥0.25 ng/mL	31/98 (31.6)	6/19 (31.6)	17/58 (29.3)	8/21 (38.1)	0.759	5/17 (29.4)	12/33 (36.4)	7/26 (26.9)	7/22 (31.8)	0.886
≥0.5 ng/mL	24/98 (24.5)	6/19 (31.6)	11/58 (19.0)	7/21 (33.3)	0.307	5/17 (29.4)	9/33 (27.3)	5/26 (19.2)	5/22 (22.7)	0.853
≥1 ng/mL	18/98 (18.4)	4/19 (21.1)	10/58 (17.2)	4/21 (19.1)	0.929	4/17 (23.5)	8/33 (24.2)	1/26 (3.9)	5/22 (22.7)	0.172
Imaging on admission										
Chest radiography										
No infiltrates	35 (17.5)	6 (15.8)	22 (19.0)	7 (15.2)	0.085	9 (17.7)	10 (18.9)	9 (19.6)	7 (14.0)	0.300
Unilateral infiltrates	54 (27.0)	17 (44.7)	27 (23.3)	10 (21.7)		13 (25.5)	9 (16.9)	12 (26.1)	20 (40.0)	
Bilateral infiltrates	111 (55.5)	15 (39.5)	67 (57.8)	29 (63.0)		29 (56.9)	34 (64.2)	25 (54.4)	23 (46.0)	
Chest computed tomography										
No ground glass opacities	8/17 (47.1)	2/4 (50.0)	5/9 (55.6)	1/4 (25.0)	0.376	1/1 (100)	2/7 (28.6)	3/6 (50.0)	2/3 (66.7)	0.806
Unilateral ground glass opacities	3/17 (17.7)	0/4 (0.0)	1/9 (11.1)	2/4 (50.0)		0/1 (0.0)	2/7 (28.6)	1/6 (16.7)	0/3 (0.0)	
Bilateral ground glass opacities	6/17 (35.3)	2/4 (50.0)	3/9 (33.3)	1/4 (25.0)		0/1 (0.0)	3/7 (42.8)	2/6 (33.3)	1/3 (33.3)	

Notes: (1) The laboratory values and imaging findings are presented as no./total no. (%) unless specified differently. (2) *p*-Values refer to Chi-square test/ANOVA and the letters denote the columns with which a statistically significant pairwise comparison exists (Bonferroni's method).
Abbreviations: BMI = body mass index, IQR = interquartile range, no. = number, g = gram, ng = nanogram, μg = microgram, mg = milligram, L = liter, μL = microliter, dL = deciliter, mL = milliliter, U = unit, AST = aspartate aminotransferase, ALT = alanine aminotransferase, CK = creatinine kinase, LDH = lactic dehydrogenase.

BMI < 25 kg/m^2 and BMI ≥ 35 kg/m^2 groups allow to make a hypothesis of a J-shaped distribution between BMI and mortality. However, this was not confirmed in our adjusted analysis presumably because of our small sample and the inherent co-existing factors associated with BMI < 25 (older age, frailty).

Other preliminary published data have linked obesity to severe COVID-19. A large cohort from New York City depicted that obesity is strongly associated with progression to critical illness with substantially higher odds ratio than any cardiovascular or pulmonary disease (BMI 30–40 kg/m^2 OR: 1.38; 95% CI: 1.03–1.85; BMI > 40 kg/m^2 OR: 1.73; 95% CI: 1.03–2.90) [17]. A cohort from China revealed that obesity significantly increases the risk for developing severe pneumonia in the setting of COVID-19 (OR: 3.42; 95% CI: 1.42–8.27) [18]. Another report from China indicated that the presence of obesity in patients with metabolic-associated fatty liver disease is associated with an almost 6-fold increased risk of severe COVID-19 [19]. Obesity could partially explain why the mortality rate for COVID-19 is higher in countries with higher prevalence of obesity, such as Italy, as compared to China and Japan [20]. Variables such as diabetes and other cardiovascular and pulmonary comorbidities were found to have a significant association in prior reports from China and Italy [11–14]. However, most of these were obtained from univariate estimates only. In our multivariate analyses it was shown that these co-morbidities are likely epiphenomena since they are not independent from male gender, older age or obesity which may be the underlying link.

Table 4
In-hospital outcomes.

Outcomes	All patients	BMI group				Age group				
No./total no. (%)	N = 200	BMI < 25 (N = 38) (a)	BMI 25–34 (N = 116) (b)	BMI ≥ 35 (N = 46) (c)	*p*-Value	≤50 (N = 51) (a)	51–64 (N = 53) (b)	65–73 (N = 46) (c)	≥74 (N = 50) (d)	*p*-Value
Mortality	48 (24.0)	12 (31.6)	20 (17.2)[c]	16(34.8)[b]	0.030	6 (11.8)[d]	12 (22.6)	10 (21.7)	20 (40.0)[a]	0.010
Intubation	42 (21.0)	7 (18.4)	19 (16.4)[c]	16 (34.8)[b]	0.032	5 (9.8)[c]	12 (22.6)	15 (32.6)[a]	10 (20.0)	0.052
↑ O_2 requirement	90 (45.0)	17 (44.7)	46 (39.7)	27 (58.7)	0.090	18 (35.3)	25 (47.2)	22 (47.8)	25 (50.0)	0.441
ARDS	45 (22.5)	6 (15.8)	25 (21.6)	14 (30.4)	0.259	9 (17.7)	10 (18.9)	13 (28.3)	13 (26.0)	0.509
ICU	32 (16.0)	3 (7.89)	18 (15.5)	11 (23.9)	0.134	5 (9.8)	11 (20.8)	12 (26.1)[d]	4 (8.0)[c]	0.042
AKI	70 (35.0)	13 (34.2)	39 (33.6)	18 (39.4)	0.798	7 (13.7)[d]	19 (35.9)	20 (43.5)	24 (48.0)[a]	0.002
RRT	16 (8.0)	1 (2.6)	9 (7.8)	6 (13)	0.216	2 (3.9)	5 (9.6)	5 (10.9)	4 (8.00)	0.606
Length of stay median (IQR) - days	6 (4–10)	6 (4–12)	5 (4–10)	6 (4–9)	0.924	5 (4–7)	7 (5–12)	6 (4–11.5)	6 (4–11)	0.273

Notes: (1) The outcomes are presented as no. (%) unless specified differently. (2) *p*-Values refer to Chi-square test/ANOVA and the letters denote the columns with which a statistically significant pairwise comparison exists (Bonferroni's method).
Abbreviations and symbols: BMI = body mass index, IQR = interquartile range, no. = number, O_2 = oxygen, ↑ = increasing, ARDS = acute respiratory distress syndrome, ICU = intensive care unit, AKI = acute kidney injury, RRT = renal replacement therapy.

Our findings on the association of severe obesity to mortality in COVID-19 are not unanticipated given our prior experience from the 2009 pandemic influenza (H1N1) disease. Morgan et al. reported significant association of obesity to death in adult patients without recognized pre-existing medical conditions hospitalized with H1N1 influenza disease (obesity OR: 3.1; 95% CI: 1.5–6.6; morbid obesity OR: 7.6; 95% CI: 2.1–27.9) [21]. Obesity leads to increased work of breathing by augmenting the airway resistance and is associated with decreased expiratory reserve volume, functional capacity, and pulmonary compliance [22,23]. Central obesity results in decreased diaphragmatic excursion in supine patients compromising ventilation [23]. Moreover, obesity is a chronic inflammatory state with increased circulating levels of pro-inflammatory cytokines, including interleukin-6, and is known to impair the immune system [24,25]. The observed association between severe obesity and mortality may also underlie the observed association between low vitamin D levels, which are low in the obese, and mortality and needs to be explored further [25].

The in-hospital mortality rate on 21-day follow-up in our cohort is 24%. Three inpatient cohorts from China reported in-hospital mortality

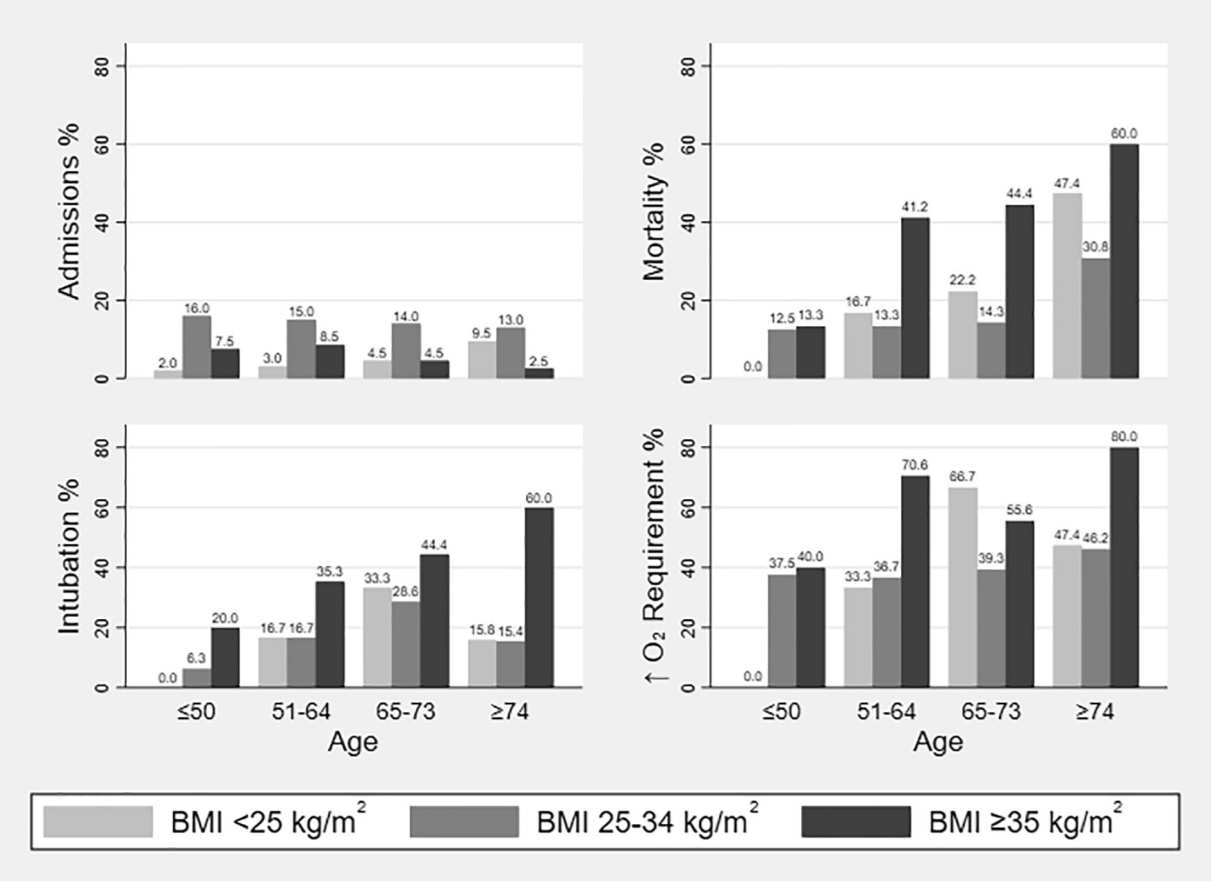

Fig. 1. Study population, in-hospital mortality and secondary outcomes per age group (≤50, 51–64, 65–73, and ≥74 years) and body mass index (BMI <25, 25–34, and ≥35 kg/m^2).

Table 5
Univariate and multivariate logistic regression analyses for in-hospital mortality.

Variable		Univariate	Multivariate		
			(1)	(2)	(3)
		OR, 95% CI, *p*-value	OR, 95% CI, *p*-value	OR, 95% CI, *p*-value	OR, 95% CI, *p*-value
Male sex		2.31 (1.18–4.54) $p = 0.015$		2.76 (1.29–5.93) $p = 0.009$	2.74 (1.25–5.98) $p = 0.011$
Age (quartiles)		1.61 (1.19–2.20) $p = 0.002$	1.75 (1.23–2.49) $p = 0.002$	1.74 (1.15–2.65) $p = 0.009$	1.73 (1.13–2.63) $p = 0.011$
African American or Hispanic		0.45 (0.20–1.04) $p = 0.062$			
BMI (<25) (25–34) (≥35)		1.15 (0.65–2.02) $p = 0.637$			
BMI (<25) (25–29) (≥30)		0.79 (0.52–1.21) $p = 0.281$			
BMI (ref. 25–34)	<25	2.22 (0.96–5.13) $p = 0.063$	1.57 (0.68–3.66) $p = 0.294$	1.31 (0.50–3.45) $p = 0.587$	1.37 (0.52–3.64) $p = 0.527$
	≥35	2.56 (1.18–5.57) $p = 0.018$	3.35 (1.43–7.87) $p = 0.005$	3.94 (1.56–9.92) $p = 0.004$	3.78 (1.45–9.83) $p = 0.006$
Heart failure		3.18 (1.46–6.93) $p = 0.004$		1.46 (0.52–4.13) $p = 0.471$	1.43 (0.50–4.06) $p = 0.501$
Coronary artery disease		2.88 (1.31–6.34) $p = 0.008$		1.56 (0.57–4.30) $p = 0.389$	1.53 (0.54–4.34) $p = 0.421$
Diabetes		1.76 (0.91–3.40) $p = 0.091$			1.16 (0.55–2.44) $p = 0.698$
CKD or ESRD		2.14 (1.08–4.24) $p = 0.029$		1.16 (0.50–2.69) $p = 0.723$	1.15 (0.49–2.68) $p = 0.746$
COPD		3.39 (1.48–7.80) $p = 0.004$		1.85 (0.75–4.56) $p = 0.182$	2.05 (0.76–5.51) $p = 0.156$
Residence status (community vs SNF)		0.90 (0.42–1.91) $p = 0.779$			
Current or former smoker		1.19 (0.60–2.36) $p = 0.622$			0.83 (0.37–1.87) $p = 0.647$
Alcohol use		0.61 (0.17–2.21) $p = 0.450$			
Intravenous drug use		0.44 (0.05–3.69) $p = 0.450$			
ACEI or ARB use prior to admission		0.78 (0.38–1.61) $p = 0.503$			
Cerebrovascular disease		0.92 (0.32–2.66) $p = 0.883$			
Hypertension		0.93 (0.44–1.98) $p = 0.853$			
Hyperlipidemia		1.09 (0.57–2.10) $p = 0.789$			
Asthma		0.51 (0.17–1.56) $p = 0.238$			
Obstructive sleep apnea		2.27 (0.76–6.76) $p = 0.141$			
Active malignancy		1.88 (0.53–6.75) $p = 0.331$			
On immunosuppressive therapy		0.66 (0.18–2.40) $p = 0.525$			
Any disorder		1.11 (0.35–3.58) $p = 0.854$			
Income (above sample median)		1.56 (0.80–3.00) $p = 0.188$			

Notes: (1) Multivariate analysis with age (quartiles), BMI <25 and BMI ≥35 as regressors, (2) multivariate analysis with addition of all statistically significant variables of the univariate analysis as regressors, (3) multivariate analysis with addition of smoking and diabetes clinical important ones as regressors. Median income was estimated by zip codes. Age in years. BMI in kg/m^2. For all calculations heteroscedastic adjusted standard errors were used.
Abbreviations: BMI = body mass index, CKD = chronic kidney disease, ESRD = end-stage renal disease, COPD = chronic obstructive pulmonary disease, SNF = skilled nursing facility, ACEi = angiotensin-converting-enzyme inhibitor, ARB = angiotensin II receptor blocker, CI = confidence interval, Ref. = reference.

Table 6
Univariate and multivariate logistic regression analyses for increasing oxygen requirements.

Variable		Univariate	Multivariate		
			(1)	(2)	(3)
		OR, 95% CI, *p*-value	OR, 95% CI, *p*-value	OR, 95% CI, *p*-value	OR, 95% CI, *p*-value
Male sex		2.25 (1.27–3.98) $p = 0.005$		2.71 (1.48–4.98) $p = 0.001$	2.77 (1.48–5.19) $p = 0.001$
Age (quartiles)		1.20 (0.93–1.54) $p = 0.154$	1.28 (0.98–1.67) $p = 0.070$	1.37 (1.03–1.82) $p = 0.033$	1.38 (1.01–1.89) $p = 0.042$
African American or Hispanic		0.86 (0.39–1.89) $p = 0.702$			
BMI (<25) (25–34) (≥35)		1.37 (0.88–2.13) $p = 0.170$			
BMI (<25) (25–29) (≥30)		1.09 (0.76–1.58) $p = 0.628$			
BMI (ref. 25–34)	<25	1.23 (0.59–2.59) $p = 0.582$	1.04 (0.49–2.20) $p = 0.928$	0.83 (0.38–1.80) $p = 0.635$	0.95 (0.43–2.11) $p = 0.893$
	≥35	2.16 (1.08–4.34) $p = 0.030$	2.37 (1.17–4.82) $p = 0.017$	2.99 (1.44–6.21) $p = 0.003$	3.09 (1.43–6.69) $p = 0.004$
Heart failure		0.96 (0.45–2.02) $p = 0.910$			0.56 (0.22–1.44) $p = 0.229$
Coronary artery disease		1.37 (0.65–2.90) $p = 0.413$			1.23 (0.51–2.94) $p = 0.641$
Diabetes		1.46 (0.82–2.58) $p = 0.198$			1.13 (0.60–2.14) $p = 0.710$
CKD or ESRD		1.46 (0.79–2.71) $p = 0.224$			1.00 (0.48–2.12) $p = 0.991$
COPD		1.77 (0.79–3.97) $p = 0.168$			1.02 (0.40–2.59) $p = 0.964$
Residence status (community vs SNF)		1.14 (0.59–2.21) $p = 0.701$			
Current or former smoker		1.86 (1.02–3.39) $p = 0.042$		2.10 (1.11–3.96) $p = 0.022$	2.10 (1.07–4.10) $p = 0.031$
Alcohol use		2.05 (0.76–5.54) $p = 0.157$			
Intravenous drug use		1.23 (0.30–5.09) $p = 0.773$			
ACEI or ARB use prior to admission		0.84 (0.46–1.53) $p = 0.560$			
Cerebrovascular disease		0.83 (0.34–2.04) $p = 0.684$			
Hypertension		0.86 (0.45–1.64) $p = 0.642$			
Hyperlipidemia		1.22 (0.69–2.13) $p = 0.496$			
Asthma		0.57 (0.24–1.34) $p = 0.195$			
Obstructive sleep apnea		1.08 (0.37–3.10) $p = 0.893$			
Active malignancy		1.50 (0.44–5.10) $p = 0.516$			
On immunosuppressive therapy		0.84 (0.31–2.32) $p = 0.741$			
Any disorder		1.32 (0.49–3.55) $p = -0.587$			
Income (above sample median)		1.00 (0.57–1.75) $p = 1.000$			

Notes: (1) Multivariate analysis with age (quartiles), BMI <25 and BMI ≥35 as regressors, (2) multivariate analysis with addition of all statistically significant variables of the univariate analysis as regressors, (3) multivariate analysis with addition of smoking and diabetes clinical important ones as regressors. Median income was estimated by zip codes. Age in years. BMI in kg/m^2. For all calculations heteroscedastic adjusted standard errors were used.
Abbreviations: BMI = body mass index, CKD = chronic kidney disease, ESRD = end-stage renal disease, COPD = chronic obstructive pulmonary disease, SNF = skilled nursing facility, ACEi = angiotensin-converting-enzyme inhibitor, ARB = angiotensin II receptor blocker, CI = confidence interval, Ref. = reference.

Table 7
Univariate and multivariate logistic regression analyses for intubation.

Variable		Univariate	Multivariate		
			(1)	(2)	(3)
		OR, 95% CI, *p*-value	OR, 95% CI, *p*-value	OR, 95% CI, *p*-value	OR, 95% CI, *p*-value
Male sex		2.51 (1.23–5.14) $p = 0.012$		3.39 (1.56–7.39) $p = 0.002$	3.35 (1.51–7.46) $p = 0.003$
Age (quartiles)		1.27 (0.97–1.68) $p = 0.087$	1.45 (1.06–1.97) $p = 0.019$	1.60 (1.15–2.22) $p = 0.005$	1.50 (1.05–2.12) $p = 0.025$
African American or Hispanic		0.65 (0.27–1.60) $p = 0.350$			
BMI (<25) (25–34) (≥35)		1.72 (0.94–3.12) $p = 0.077$			
BMI (<25) (25–29) (≥30)		0.79 (0.52–1.20) $p = 0.281$			
BMI (ref. 25–34)	<25	1.15 (0.44–3.01) $p = 0.771$	0.90 (0.33–2.44) $p = 0.829$	0.79 (0.28–2.17) $p = 0.643$	0.76 (0.26–2.22) $p = 0.613$
	≥35	2.72 (1.24–5.96) $p = 0.012$	3.19 (1.42–7.17) $p = 0.005$	4.06 (1.72–9.57) $p = 0.001$	3.87 (1.47–10.18) $p = 0.006$
Heart failure		1.45 (0.62–3.41) $p = 0.393$			
Coronary artery disease		1.25 (0.52–3.03) $p = 0.618$			
Diabetes		1.95 (0.98–3.88) $p = 0.058$			1.26 (0.58–2.73) $p = 0.557$
CKD or ESRD		1.30 (0.62–2.69) $p = 0.488$			
COPD		2.00 (0.83–4.82) $p = 0.125$			
Residence status (community vs SNF)		1.39 (0.59–3.27) $p = 0.446$			
Current or former smoker		1.56 (0.77–3.15) $p = 0.217$			1.66 (0.76–3.62) $p = 0.206$
Alcohol use		1.51 (0.50–4.51) $p = 0.463$			
Intravenous drug use		1.27 (0.25–6.54) $p = 0.778$			
ACEI or ARB use prior to admission		0.64 (0.29–1.40) $p = 0.261$			
Cerebrovascular disease		0.56 (0.16–2.01) $p = 0.376$			
Hypertension		0.63 (0.30–1.35) $p = 0.239$			
Hyperlipidemia		1.98 (0.99–3.96) $p = 0.055$			1.66 (0.78–3.55) $p = 0.188$
Asthma		0.62 (0.20–1.90) $p = 0.401$			
Obstructive sleep apnea		2.76 (0.92–8.27) $p = 0.070$			1.15 (0.40–3.35) $p = 0.791$
Active malignancy		1.44 (0.36–5.71) $p = 0.602$			
On immunosuppressive therapy		0.79 (0.22–2.90) $p = 0.724$			
Any disorder		0.66 (0.22–1.98) $p = 0.463$			
Income (above sample median)		1.27 (0.64–2.53) $p = 0.489$			

Notes: (1) Multivariate analysis with age (quartiles), BMI <25 and BMI ≥35 as regressors, (2) multivariate analysis with addition of all statistically significant variables of the univariate analysis as regressors, (3) multivariate analysis with addition of smoking and diabetes clinical important ones as regressors. Median income was estimated by zip codes. Age in years. BMI in kg/m^2. For all calculations heteroscedastic adjusted standard errors were used.
Abbreviations: BMI = body mass index, CKD = chronic kidney disease, ESRD = end-stage renal disease, COPD = chronic obstructive pulmonary disease, SNF = skilled nursing facility, ACEi = angiotensin-converting-enzyme inhibitor, ARB = angiotensin II receptor blocker, CI = confidence interval, Ref. = reference.

rates of 28.2%, 11.7%, and 17%, respectively [5,11,12]. A large cross-sectional study from New York City, which did not include hospitals located in the Bronx, reported a 14.6% mortality rate in the inpatient sample to the time of the analysis, however 35.9% of the patients were still hospitalized, which indicates that the final inpatient mortality rate may be actually higher [16]. Large retrospective cohorts that will probably be published in the following months will accurately estimate the in-hospital mortality in the Bronx and elsewhere.

In total, 33.6% of adults in the Bronx are obese, a number which is much higher than all other NYC boroughs, while the prevalence of obesity nationally is 20% [9,10]. The Bronx has the highest rate of diabetes among all sixty-two counties of the New York state and one of the highest rates of hypertension [26]. Additionally, the prevalence of obesity is higher among individuals of lower socioeconomic status (>35%) and substantially higher in non-Hispanic blacks (36%) and Hispanic (35.4%) as compared to non-Hispanic whites (19.1%) [9]. The patient population that our institution serves mainly includes patients of lower socioeconomic status and people that identify themselves as African American or Hispanic. The combination of these two made up 85.5% of our current study population that is representative of racial and ethnical distribution in the Bronx [27]. The median income, as estimated by the zip codes based on publicly available data provided by the internal revenue service, was not found to be a risk factor for worse outcomes in our study, which is explained by the fact that the Bronx is a homogenous area of low income.

We report that active or prior smoking was associated with increasing oxygen requirements during hospitalization. This is in contrast to the results of a recent meta-analysis of five studies from China which concluded that active smoking did not seem to be significantly associated with higher risk of progressing to severe COVID-19 [28]. Large observational studies and future meta-analyses will elucidate the association of smoking with COVID-19 severity and other outcomes.

One of the strengths of the current study is that our included patients represent underserved and economically disadvantaged minorities; thus, revealing the early outcomes of COVID-19 in this vulnerable population and usually underreported and underrepresented in clinical research. Additionally, two researchers independently and blindly collected data which reduces errors and bias. On the other hand, our study has several limitations. First, our sample was relatively small, but given the nature of the evolving pandemic, it was of paramount importance to make our early data and findings widely available as soon as possible, especially given the lack of data up to date in COVID-19 in minorities and underserved population. We noted that among elderly, not only high BMI but also BMI <25 was associated with worse in-hospital outcomes. Therefore, we proceeded to interaction analyses between variables that were shown to be associated with the outcomes in the adjusted analyses (BMI, age, sex) but no correlation was found. Given that our study size was relatively small, future larger studies need to explore effect modification and the interaction between these variables. Second, this was a real-world study with a retrospective design utilizing the electronic medical records, which is suboptimal compared to a prospective study that could have more accurate follow-up assessment. Third, the rapidly changing management of COVID-19 might have affected our results but it is highly unlikely that this could have differentially affected associations between obesity and mortality. Fourth, we handled BMI as a categorical variable in the regression analysis with cut-off points largely representing quartiles of BMI. However, we also performed additional analyses with BMI as a dichotomous (cut-off: 35 kg/m^2) or a continuous variable and the significant associations persisted.

In conclusion in this cohort of hospitalized patients with COVID-19 in an underserved, minority- predominant population in the Bronx, we found that severe obesity was associated with higher in-hospital mortality even after adjusting for other pertinent potentially confounding factors. Particular attention should be paid in preventing obesity and its complications and protecting this population from COVID-19 given

Table 8
Univariate and multivariate logistic regression analyses with Age and BMI as continuous variables, and BMI (≥35) as dichotomous.

Variable	Univariate	Multivariate			
		(1)	(2)	(3)	(4)
	OR, 95% CI, *p*-value	OR, 95% CI, *p*-value	OR, 95% CI, *p*-value	OR, 95% CI, *p*-value	OR, 95% CI, *p*-value
Panel A: In-hospital mortality					
Male sex		3.46 (1.63–7.32) $p = 0.001$	3.08 (1.50–6.36) $p = 0.002$	2.86 (1.30–6.32) $p = 0.009$	2.53 (1.19–5.40) $p = 0.016$
Age	1.03 (1.01–1.06) $p = 0.011$	1.05 (1.02–1.08) $p = 0.002$	1.05 (1.02–1.08) $p = 0.004$	1.04 (1.00–1.08) $p = 0.030$	1.03 (1.00–1.07) $p = 0.041$
BMI ≥35	2.03 (0.99–4.19) $p = 0.054$	3.77 (1.55–9.19) $p = 0.003$		3.34 (1.34–8.34) $p = 0.010$	
BMI	1.01 (0.96–1.05) $p = 0.753$		1.05 (1.00–1.10) $p = 0.071$		1.04 (0.99–1.09) $p = 0.122$
Heart failure				1.57 (0.59–4.21) $p = 0.369$	1.73 (0.66–4.49) $p = 0.262$
Coronary artery disease				1.46 (0.54–3.96) $p = 0.461$	1.32 (0.49–3.58) $p = 0.586$
Diabetes				1.16 (0.56–2.42) $p = 0.683$	1.23 (0.60–2.54) $p = 0.575$
CKD or ESRD				1.25 (0.54–2.89) $p = 0.608$	1.28 (0.57–2.89) $p = 0.551$
COPD				1.96 (0.73–5.31) $p = 0.183$	2.09 (0.73–6.01) $p = 0.169$
Current or former smoker				0.81 (0.36–1.83) $p = 0.620$	0.78 (0.35–1.73) $p = 0.536$
Panel B: Increasing oxygen requirements					
Male sex		2.75 (1.51–5.00) $p = 0.001$	2.71 (1.49–4.90) $p = 0.001$	2.86 (1.50–5.46) $p = 0.001$	2.77 (1.47–5.21) $p = 0.002$
Age	1.01 (1.00–1.03) $p = 0.155$	1.02 (1.00–1.04) $p = 0.025$	1.03 (1.00–1.05) $p = 0.018$	1.02 (1.00–1.05) $p = 0.050$	1.02 (1.00–1.05) $p = 0.044$
BMI ≥35	2.05 (1.05–4.01) $p = 0.036$	2.80 (1.39–5.62) $p = 0.004$		3.10 (1.47–6.54) $p = 0.003$	
BMI	1.02 (0.99–1.06) $p = 0.192$		1.05 (1.01–1.09) $p = 0.017$		1.05 (1.01–1.10) $p = 0.014$
Heart failure				0.55 (0.22–1.40) $p = 0.209$	0.61 (0.24–1.54) $p = 0.299$
Coronary artery disease				1.22 (0.52–2.87) $p = 0.653$	1.13 (0.47–2.71) $p = 0.778$
Diabetes				1.13 (0.60–2.15) $p = 0.698$	1.18 (0.62–2.22) $p = 0.620$
CKD or ESRD				1.04 (0.49–2.20) $p = 0.921$	1.08 (0.51–2.28) $p = 0.838$
COPD				1.01 (0.40–2.55) $p = 0.989$	1.04 (0.40–2.70) $p = 0.934$
Current or former smoker				2.00 (1.03–3.88) $p = 0.040$	1.95 (1.02–3.74) $p = 0.045$
Panel C: Intubation					
Male sex		3.58 (1.58–8.08) $p = 0.002$	3.14 (1.45–6.78) $p = 0.004$	3.45 (1.51–7.91) $p = 0.003$	2.96 (1.35–6.46) $p = 0.006$
Age	1.02 (1.00–1.04) $p = 0.097$	1.04 (1.01–1.06) $p = 0.009$	1.03 (1.01–1.06) $p = 0.016$	1.03 (1.00–1.06) $p = 0.042$	1.03 (1.00–1.05) $p = 0.071$
BMI ≥35	2.63 (1.25–5.51) $p = 0.011$	4.34 (1.83–10.26) $p = 0.001$		4.06 (1.54–10.73) $p = 0.005$	
BMI	1.02 (0.98–1.06) $p = 0.294$		1.05 (1.01–1.10) $p = 0.026$		1.04 (0.99–1.09) $p = 0.127$
Diabetes				1.27 (0.59–2.75) $p = 0.538$	1.40 (0.66–2.96) $p = 0.383$
Current or former smoker				1.53 (0.71–3.29) $p = 0.278$	1.45 (0.69–3.05) $p = 0.322$
Hyperlipidemia				1.66 (0.78–3.52) $p = 0.189$	1.59 (0.76–3.35) $p = 0.219$
Obstructive sleep apnea				1.19 (0.41–3.46) $p = 0.747$	1.81 (0.58–5.62) $p = 0.303$

Notes: (1) Multivariate analysis with gender, age and BMI ≥ 35 as regressors, (2) multivariate analysis with gender, age and BMI as regressors, (3) multivariate analysis with the regressors of columns 3 of Tables 5, 6 and 7 for panels A, B and C with (Age and BMI ≥ 35), respectively. (4) Multivariate analysis with the regressors of columns 3 of Tables 5, 6 and 7 for panels A, B and C with (Age and BMI), respectively. Age in years. BMI in kg/m^2. For all calculations heteroscedastic adjusted standard errors were used.
Abbreviations: OR: odds ratios, CI: confidence interval, BMI: Body metabolic index; CKD: Chronic kidney disease; ESRD: End stage renal disease; COPD: Chronic obstructive pulmonary disease.

the higher chance for adverse outcomes once they are diagnosed with the disease. In addition, obese patients diagnosed with COVID-19 should be treated with particular attention given the possible higher risk for adverse outcomes. While we recognize the limitations, we hope that our study will stimulate additional researchers to further study the effect of obesity in COVID-19 and outcomes of minorities diagnosed with COVID-19. Larger cohort studies are needed to confirm our data and pilot clinical trials are needed to assess whether pharmacotherapy for obesity and its comorbidities may improve outcomes in the short or the long term.

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CRediT authorship contribution statement

Leonidas Palaiodimos: Conceptualization, Methodology, Data curation, Investigation, Validation, Writing - original draft. **Damianos G. Kokkinidis:** Conceptualization, Methodology, Formal analysis, Investigation, Writing - original draft. **Weijia Li:** Data curation, Investigation, Visualization, Resources. **Dimitrios Karamanis:** Methodology, Software, Formal analysis, Investigation, Visualization. **Jennifer Ognibene:** Software, Resources, Data curation, Visualization. **Shitij Arora:** Validation, Investigation, Writing - review & editing. **William N. Southern:** Validation, Investigation, Writing - review & editing. **Christos S. Mantzoros:** Investigation, Formal analysis, Validation, Writing - review & editing, Supervision, Methodology.

Declaration of competing interest

All authors declare no conflict of interests.

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