Advances in Clinical Medical Research and Healthcare Delivery

Volume 2 | Issue 3 Article 3

2022

Obesity and COVID-19 Outcomes in a Primarily Black Population

Raj Dangol
raj.k.dangol@medstar.net

Olga Lurye
olga.i.lurye@medstar.net

Sadaf Mustafa
sadaf.mustafa@medstar.net

Lyn Camire
lyn.camire@medstar.net

Krupa Patel
krupa.s.patel@medstar.net

Eshetu Tefera
eshetu.tefera@medstar.net

David S. Weisman
MedStar Union Memorial Hospital, Baltimore, MD, USA and Georgetown University School of Medicine, Washington, DC, USA, david.s.weisman@medstar.net

Recommended Citation

Dangol R, Lurye O, Mustafa S, Camire L, Patel K, Tefera E, Weisman DS. Obesity and COVID-19 Outcomes in a Primarily Black Population. *Advances in Clinical Medical Research and Healthcare Delivery*. 2022; 2(3). doi: 10.53785/2769-2779.1098.

ISSN: 2769-2779

Obesity and COVID-19 Outcomes in a Primarily Black Population

Author ORCID ID:
https://orcid.org/0000-0001-5082-8955 (David Weisman)

Abstract

ABSTRACT

Background:

Studies have noted higher COVID-19 mortality with more severe obesity in populations that included a small percentage of Black patients.

Methods:

We retrospectively analyzed COVID-19 outcomes associated with obesity in our largely African American patient population. A total of 1101 symptomatic patients with a positive COVID-19 laboratory test March 5 to June 3, 2020, were categorized into weight groups based on body mass index (BMI). Of these patients, 679 (61.7%) were Black. A total of 355 (32.2%) patients had overweight and 516 (46.9%) had obesity.

Results:

BMI was an independent risk factor for intubation and an independent predictor for ICU length of stay and intubation days. An unexpected observation was favorable outcomes in mild obesity compared with normal weight and more severe obesity, likely a result of older age and higher Charlson comorbidity index in patients with normal BMI compared with patients with mild obesity.

Conclusions:

In a diverse primarily Black population, comorbidities were a concern for adverse COVID-19 outcomes and COVID-19 outcomes were significantly worse with moderate and severe obesity.

Conflict of Interest Statement

The authors have no conflict of interest in connection with this article.

Cover Page Footnote

We thank the Georgetown Summer Research Project for funding for statistical analysis funding. We also thank the following individuals for assistance with data extraction: Lindsay Jory, MD, Arjun Kanwal, MD, Mary Zulty, DO, William Merwin, MD, Nahar Saleh, MD, Nawar Suleman, MD, Rowena D'Souza, MBBS, Mekdem Melaku, MD, Niloofar Yahyapourjalaly, MD, and Ashwini Bhat, MBBS, of MedStar Union Memorial Hospital, Baltimore, Maryland, and Krystal Henderson, BS, and Kevin Delijani, BS, of Georgetown University School of Medicine, Washington, DC.

ARTICLE

Obesity and COVID-19 Outcomes in a Primarily Black Population

Raj K. Dangol [a,b], Olga Lurye [a,b], Sadaf Mustafa [a,b], Lyn Camire [a], Krupa Patel [a,b], Eshetu Tefera [c], David S. Weisman[a,b,*]

[a] MedStar Union Memorial Hospital, Baltimore, MD, USA
[b] Medicine, Georgetown University Medical Center, Washington, DC, USA
[c] MedStar Health Research Institute, Hyattsville, MD, USA

Abstract

Background: **Studies have noted higher COVID-19 mortality with more severe obesity in populations that included a small percentage of Black patients.**

Methods: **We retrospectively analyzed COVID-19 outcomes associated with obesity in our largely African American patient population. A total of 1101 symptomatic patients with a positive COVID-19 laboratory test March 5 to June 3, 2020, were categorized into weight groups based on body mass index (BMI). Of these patients, 679 (61.7%) were Black. A total of 355 (32.2%) patients had overweight and 516 (46.9%) had obesity.**

Results: **BMI was an independent risk factor for intubation and an independent predictor for ICU length of stay and intubation days. An unexpected observation was favorable outcomes in mild obesity compared with normal weight and more severe obesity, likely a result of older age and higher Charlson comorbidity index in patients with normal BMI compared with patients with mild obesity.**

Conclusions: **In a diverse primarily Black population, comorbidities were a concern for adverse COVID-19 outcomes and COVID-19 outcomes were significantly worse with moderate and severe obesity.**

1. Introduction

Obesity is a major global public health emergency. In the United States, obesity has been reported in 42.4% of the adult population.[1] Studies have noted a J-shaped curve for in-hospital COVID-19 mortality in diverse patient populations, with the highest rate in underweight patients and the lowest in overweight patients, with increasing mortality with more severe obesity.[2,3] A significantly higher in-hospital death rate from COVID-19 was observed with severe obesity >40 kg/m^2 in a predominantly Hispanic population.[3] Another report found a dose–response relationship between higher body mass index (BMI) and risk for hospitalization, ICU admission, invasive mechanical ventilation, and death from COVID-19 in a majority white non-Hispanic population.[4]

Higher rates of hospitalization with COVID-19 have been reported for Blacks, but not higher COVID-19 in-hospital mortality compared with patients of white race.[5] However, Black patients accounted for only 18% of the study population in the COVID-19 obesity report with the largest percentage of Black patients, and that study did not consider comorbidities.[4]

We thank the Georgetown Summer Research Project for funding for statistical analysis funding. We also thank the following individuals for assistance with data extraction: Lindsay Jory, MD, Arjun Kanwal, MD, Mary Zulty, DO, William Merwin, MD, Nahar Saleh, MD, Nawar Suleman, MD, Rowena D'Souza, MBBS, Mekdem Melaku, MD, Niloofar Yahyapourjalaly, MD, and Ashwini Bhat, MBBS, of MedStar Union Memorial Hospital, Baltimore, Maryland, and Krystal Henderson, BS, and Kevin Delijani, BS, of Georgetown University School of Medicine, Washington, DC.

Advances in Clinical Medical Research and Healthcare Delivery

Accepted 5 August 2022.
Available online 12 September 2022

* Corresponding author at: Department of Medicine, MedStar Union Memorial Hospital, 201 East University Parkway, Baltimore, MD 21218, USA.
E-mail address: david.s.weisman@medstar.net (D.S. Weisman).

https://doi.org/10.53785/2769-2779.1098

Table 1. Baseline characteristics by BMI group.

Factor	BMI							P value
	Overall (n = 1101)	Normal (n = 211)	Underweight (n = 19)	Overweight (n = 355)	Obesity			
					Mild (class I) (n = 221)	Moderate (class II) (n = 141)	Severe (class III) (n = 154)	
Age, y±SD	62.5 ± 16.0	69.9 ± 16.4	80.3 ± 11.4	63.7 ± 14.9	59.7 ± 14.6	59.2 ± 14.1	54.5 ± 15.7	<.0001
Sex								<.0001
Female, n (%)	523 (47.5)	90 (42.7)	14 (73.7)	131 (36.9)	110 (49.8)	77 (54.6)	101 (65.6)	
Male, n (%)	578 (52.5)	121 (57.3)	5 (26.3)	224 (63.1)	111 (50.2)	64 (45.4)	53 (34.4)	
Race, n (%)								<.0001
Black	679 (61.7)	115 (54.5)	13 (68.4)	203 (57.2)	132 (59.7)	98 (69.5)	118 (76.6)	
White	157 (14.3)	52 (24.6)	4 (21.1)	52 (14.6)	23 (10.4)	12 (8.5)	14 (9.1)	
Non-Black, non-White†	265 (24.1)	44 (20.9)	2 (10.5)	100 (28.2)	66 (29.9)	31 (22.0)	22 (14.3)	
Current smoker, n (%)	63 (5.7)	17 (8.1)	1 (5.3)	18 (5.1)	15 (6.8)	5 (3.6)	7 (4.6)	.0006
Location prior to hospital, n (%)								<.0001
Home, n (%)	826 (75.0)	132 (62.6)	8 (42.1)	256 (72.1)	183 (82.8)	119 (84.4)	128 (83.1)	
Nursing home, n (%)	144 (13.1)	45 (21.3)	8 (42.1)	52 (14.6)	14 (6.3)	11 (7.8)	14 (9.1)	
Hypertension, n (%)	710 (64.5)	144 (68.2)	11 (57.9)	218 (61.4)	144 (65.2)	90 (63.8)	103 (66.9)	.6101
Diabetes on insulin	152 (13.8)	21 (10)	0 (0)	43 (12.1)	36 (16.3)	27 (19.1)	25 (16.2)	.0373
Diabetes not on insulin, n (%)	250 (22.7)	44 (20.9)	1 (5.3)	76 (21.4)	53 (24.0)	40 (28.4)	36 (23.4)	.2307
Charlson Comorbidity Index, mean±SD	3.4 ± 2.6	4.4 ± 2.4	5.4 ± 1.4	3.6 ± 2.7	2.9 ± 2.4	2.8 ± 2.4	2.8 ± 2.7	<.0001

BMI, body mass index. ANOVA or Kruskal–Wallis tests were used to examine differences in the averages of continuous variables between the BMI groups. Chi-square test was used to investigate differences for categorical variables.†Hispanic 192 (72.5%), 73 unknown race/ethnicity. Definitions of weight groups: underweight BMI less than 18.5 kg/m^2, normal BMI 18.5–24.9 kg/m^2, overweight BMI 25–29.9 kg/m^2, Class 1 obesity BMI 30–34.9 kg/m^2, Class 2 obesity BMI 35–39.9 kg/m^2 and Class 3 obesity was BMI 40 kg/m^2 or greater.

The purpose of this study was to analyze COVID-19 outcomes associated with obesity, taking comorbidities into account, in the largely Black patient population of our health care system.

2. Methods

This retrospective cohort study was approved as exempt with HIPAA waiver by the MedStar Institutional Review Board (Study00002706). Inclusion criteria were age 18 years or older admitted with a positive laboratory test for SARS- CoV-2, defined as a positive result on high-throughput sequencing or real-time reverse-transcriptase-PCR (RT-PCR) assay of nasal swab specimens, admission to one of 10 acute care hospitals in our system from March 5 to June 3, 2020, COVID-19 ICD-10 code in the chart, chart note stating symptomatic COVID-19 condition, and BMI data in the chart. Of 2902 charts identified, 1672 were reviewed as a consecutive series of patients. A total of 113 charts from hospitals not fully integrated into the EMR system were excluded for missing data and 458 were excluded mostly for COVID negative status or asymptomatic COVID, leaving 1101 charts for analysis. Because of resource limitations, this pilot involved review of distinct consecutive blocks of patients by multiple residents working simultaneously. A sample of 15% of charts were reviewed for accuracy by the senior author.

We used logistic regression analysis to examine the association between BMI and mortality. We examined multicollinearity through correlation

Table 2. Unadjusted primary outcomes by BMI group.

Factor	BMI							P value
	Overall (n = 1101)	Normal (n = 211)	Underweight (n = 19)	Overweight (n = 355)	Obesity			
					Mild (class I) (n = 221)	Moderate (class II) (n = 141)	Severe (class III) (n = 154)	
In-hospital mortality, n (%)	230 (20.9)	56 (26.5)	5 (26.3)	86 (24.2)	27 (12.2)	28 (19.9)	28 (18.2)	0.0034
ICU admission, n (%)	404 (36.7)	74 (35.1)	4 (21.1)	132 (37.2)	67 (30.3)	62 (44.0)	65 (42.2)	0.0444
Intubation, n (%)	254 (23.1)	40 (19.0)	1 (5.3)	90 (25.4)	41 (18.6)	44 (31.2)	38 (24.7)	0.0129
Discharge home, n (%)	636 (36.7)	93 (44.1)	5 (26.3)	203 (57.2)	155 (70.1)	86 (61.0)	94 (61.0)	<0.0001

BMI, body mass index. ICU, intensive care unit. Chi-square and Fisher exact tests (when cells had count less than 5) were used to investigate differences.

Table 3. Multivariate logistic regression analysis controlling for all variables found that BMI was not an independent predictor of COVID-19 in-hospital mortality ($p = 0.1361$).

Effect	Estimate	Odds Ratio	95% Wald Confidence Limits		P value
Underweight vs Normal	−0.124	0.883	0.290	2.693	0.827
Overweight vs Normal	0.136	1.146	0.748	1.756	0.532
Class 1 obesity vs Normal	−0.532	0.587	0.337	1.024	0.061
Class 2 obesity vs Normal	0.150	1.162	0.654	2.066	0.609
Class 3 obesity vs Normal	0.208	1.232	0.678	2.236	0.494
Age	0.036	1.037	1.019	1.055	<0.0001
Sex Male vs Female	0.424	1.527	1.098	2.124	0.012
Race Black vs White	−0.031	0.970	0.624	1.507	0.892
Race Other vs White	−0.312	0.732	0.411	1.304	0.290
CCI	0.060	1.062	0.949	1.189	0.294
COPD Yes vs No	0.161	1.175	0.711	1.943	0.530
Coronary artery disease Yes vs No	−0.026	0.975	0.610	1.558	0.915
Diabetes on insulin Yes vs No	0.512	1.668	1.039	2.678	0.034
Diabetes not on insulin Yes vs No	0.377	1.458	0.982	2.163	0.061
Hypertension Yes vs No	0.068	1.071	0.709	1.617	0.745
Atrial Fib or flutter Yes vs No	0.186	1.205	0.744	1.949	0.449
Active cancer Yes vs No	0.493	1.637	0.739	3.629	0.225
ESRD Yes vs No	0.096	1.101	0.613	1.975	0.748
CKD Stage IIIb or higher Yes vs No	0.072	1.075	0.628	1.839	0.792

CCI, comprehensive complications index; COPD, chronic obstructive pulmonary disease; atrial fib, atrial fibrillation; ESRD, end-stage renal disease; CKD, chronic kidney disease.

coefficient, variance inflation factor, and tolerance. No variable had high correlation (0.8 or higher) with any other variable. In addition, no variable had a tolerance value of below 0.1 and variance inflation value above 10, so there was no threat of multicollinearity. We used multivariate logistic regression analysis controlling for age, sex, race, Charlson comorbidity index, and comorbidities found significant in the bivariate analysis to examine whether BMI was an independent risk factor for mortality, ICU admission, intubation, and discharge destination. Multivariate linear regression analysis was used to examine whether BMI was an independent predictor of ICU length of stay (LOS) and intubation days controlling for age, sex, race, Charlson comorbidity index, and comorbidities found significant in the bivariate analysis. The goodness of fit of the logistic regression models were assessed using

Table 4. Multivariate logistic regression analysis controlling for all variables found that BMI was not an independent predictor of COVID-19 ICU admission ($p = 0.1426$).

Effect	Estimate	Odds Ratio	95% Wald Confidence Limits		P value
BMI Underweight vs Normal	−0.548	0.578	0.180	1.862	0.359
BMI Overweight vs Normal	0.053	1.055	0.728	1.529	0.778
BMI Class 1 obesity vs Normal	−0.263	0.769	0.499	1.183	0.232
BMI Class 2 obesity vs Normal	0.307	1.360	0.850	2.175	0.200
BMI Class 3 obesity vs Normal	0.194	1.214	0.753	1.959	0.426
Age	−0.009	0.991	0.978	1.004	0.169
Sex Male vs Female	0.402	1.495	1.147	1.950	0.003
Race Black vs White	0.214	1.239	0.838	1.833	0.283
Race Other vs White	−0.176	0.839	0.526	1.338	0.461
CCI	0.059	1.060	0.964	1.167	0.229
COPD Yes vs No	0.101	1.106	0.694	1.764	0.671
Coronary artery disease Yes vs No	−0.245	0.783	0.507	1.209	0.269
Diabetes on insulin Yes vs No	0.403	1.496	1.000	2.239	0.050
Diabetes not on insulin Yes vs No	0.403	1.497	1.080	2.073	0.015
Hypertension Yes vs No	0.042	1.043	0.757	1.437	0.797
Atrial Fib or flutter Yes vs No	−0.223	0.800	0.377	1.699	0.562
Active cancer Yes vs No	−0.037	0.963	0.574	1.616	0.887
ESRD Yes vs No	−0.215	0.807	0.490	1.329	0.400

BMI, body mass index; CCI, comprehensive complications index; COPD, chronic obstructive pulmonary disease; atrial fib, atrial fibrillation; ESRD, end-stage renal disease.

Table 5. Multivariate logistic regression analysis controlling for all variables found that BMI was an independent predictor of intubation ($p = 0.0267$).

Effect	Estimate	Odds Ratio	95% Wald Confidence Limits		P value
BMI Underweight vs Normal	−1.265	0.282	0.036	2.213	0.229
BMI Overweight vs Normal	0.387	1.473	0.952	2.279	0.082
BMI Class 1 obesity vs Normal	−0.017	0.983	0.588	1.646	0.949
BMI Class 2 obesity vs Normal	0.678	1.969	1.155	3.358	0.013
BMI Class 3 obesity vs Normal	0.400	1.492	0.854	2.608	0.160
Age	−0.0001	1.000	0.985	1.015	0.993
Sex Male vs Female	0.292	1.339	0.989	1.814	0.059
Race Black vs White	0.029	1.029	0.662	1.602	0.898
Race Other vs White	−0.379	0.685	0.401	1.170	0.166
CCI	0.031	1.031	0.925	1.151	0.578
COPD Yes vs No	−0.217	0.805	0.462	1.402	0.444
Coronary artery disease Yes vs No	0.021	1.021	0.629	1.657	0.933
Diabetes on insulin Yes vs No	0.407	1.503	0.957	2.360	0.077
Diabetes not on insulin Yes vs No	0.463	1.588	1.103	2.286	0.013
Hypertension Yes vs No	−0.024	0.976	0.676	1.409	0.897
Atrial Fib or flutter Yes vs No	−0.378	0.685	0.393	1.196	0.183
Active cancer Yes vs No	0.106	1.112	0.485	2.546	0.802
ESRD Yes vs No	−0.167	0.846	0.464	1.544	0.586
CKD Stage IIIb or higher Yes vs No	−0.113	0.893	0.510	1.565	0.693

BMI, body mass index; CCI, comprehensive complications index; COPD, chronic obstructive pulmonary disease; atrial fib, atrial fibrillation; ESRD, end-stage renal disease; CKD, chronic kidney disease.

Hosmer−Lemeshow test. Analyses were conducted using SAS 9.4 (SAS Institute, Cary, NC).

3. Results

A majority of patients were Black (679, 61.7%) (Table 1). The median BMI was 29.40 kg/m^2 [IQR 25.9−35.6]. Hypertension was the most common comorbid condition (64.5%), followed by diabetes (36.5%). In-hospital death occurred in 20.9% of patients (Table 2).

For patients admitted to the ICU, median ICU LOS was 8 [IQR 4−15] days overall and 9 [IQR 5−20] days for patients with severe obesity (class III, BMI >40 kg/m^2). A total of 254 patients (23.1%) required mechanical ventilation. For intubated patients, the median intubation days was 9 [IQR 5−15] days overall and 12.5 [IQR 8−21] days for patients with severe obesity.

Table 6. Multivariate logistic regression analysis controlling for all variables showing that BMI was an independent predictor of discharge destination.

Effect	Estimate	Odds Ratio	95% Wald Confidence Limits		P value
BMI Underweight vs Normal	−0.484	0.616	0.201	1.890	0.397
BMI Overweight vs Normal	0.211	1.235	0.830	1.837	0.297
BMI Class 1 obesity vs Normal	0.592	1.808	1.140	2.868	0.012
BMI Class 2 obesity vs Normal	0.066	1.068	0.641	1.782	0.800
BMI Class 3 obesity vs Normal	−0.037	0.964	0.570	1.630	0.891
Age	−0.029	0.971	0.957	0.986	0.0001
Sex Male vs Female	−0.393	0.675	0.505	0.903	0.008
Race Black vs White	0.323	1.381	0.922	2.068	0.117
Race Other vs White	1.050	2.856	1.730	4.716	<0.0001
CCI	−0.195	0.823	0.742	0.913	0.0002
COPD Yes vs No	−0.055	0.947	0.582	1.539	0.826
Coronary artery disease Yes vs No	0.064	1.066	0.684	1.662	0.778
Diabetes on insulin Yes vs No	−0.225	0.799	0.517	1.233	0.310
Diabetes not on insulin Yes vs No	0.045	1.046	0.735	1.488	0.803
Hypertension Yes vs No	−0.265	0.767	0.542	1.085	0.134
Atrial Fib or flutter Yes vs No	−0.021	0.979	0.607	1.580	0.931
Active cancer Yes vs No	0.416	1.516	0.691	3.325	0.299
ESRD Yes vs No	0.011	1.011	0.584	1.749	0.969
CKD Stage IIIb or higher Yes vs No	−0.129	0.879	0.525	1.475	0.626

BMI, body mass index; CCI, comprehensive complications index; COPD, chronic obstructive pulmonary disease; atrial fib, atrial fibrillation; ESRD, end-stage renal disease; CKD, chronic kidney disease.

In the unadjusted analysis, patients with mild obesity had significantly lower odds of in-hospital mortality compared with normal patients (odds ratio 0.385, 95% CI 0.232, 0.639; P = 0.0002). After controlling for all variables, BMI was not an independent risk factor for COVID-19 in-hospital mortality (Table 3) or ICU admission (Table 4), but was an independent risk factor for intubation (p = 0.0267; Table 5). The odds of intubation were 1.9 times higher for patients with class 2 (moderate) obesity compared with patients with normal BMI. The odds of discharge to home were 1.8 times higher for patients with class 1 (mild) obesity compared with patients with normal BMI (p = 0.0119) (Table 6).

BMI was an independent risk factor for ICU LOS (Table 7) and intubation days (Table 8). Compared with normal BMI, ICU LOS increased by an average of 1.9 days (p = 0.008) with overweight, 3.0 days (p = 0.001) with class 2 (moderate) obesity, and 3.2 days (p = 0.001) with class 3 (severe) obesity. Intubation increased by an average of 1.7 days (p = 0.004) with overweight, 2.5 days (p = 0.001) with class 2 (moderate) obesity, and 2.6 days (p = 0.001) with class 3 (severe) obesity compared with normal BMI.

Table 7. Multivariate linear regression analysis controlling for all variables found that BMI was an independent predictor of ICU LOS (p = 0.001).

Parameter	Estimate	Standard Error	t Value	P value
BMI Underweight	−1.658	1.967	−0.84	0.399
BMI Overweight	1.890	0.719	2.64	0.008
BMI Class 1 obesity	0.680	0.819	0.83	0.406
BMI Class 2 obesity	3.008	0.927	3.24	0.001
BMI Class 3 obesity	3.184	0.938	3.40	0.001
BMI Normal (ref)				
Age	−0.024	0.026	−0.94	0.348
Sex Male	0.636	0.513	1.24	0.215
Sex Female (ref)				
Race Black	−0.270	0.751	−0.36	0.720
Race Other	−0.415	0.884	−0.47	0.639
Race White (ref)				
CCI	0.098	0.189	0.52	0.604
COPD Yes	−0.565	0.914	−0.62	0.536
COPD No (ref)				
Coronary artery disease Yes	−0.197	0.840	−0.23	0.815
Coronary artery disease No (ref)				
Diabetes on insulin Yes	0.239	0.805	0.30	0.767
Diabetes on insulin No (ref)				
Diabetes not on insulin Yes	0.361	0.644	0.56	0.576
Diabetes not on insulin No (ref)				
Hypertension Yes	0.554	0.621	0.89	0.372
Hypertension No (ref)				
Atrial Fib or flutter Yes	−0.761	0.895	−0.85	0.396
Atrial Fib or flutter No (ref)				
Active cancer Yes	−0.723	1.467	−0.49	0.622
Active cancer No (ref)				
ESRD Yes	−1.045	1.028	−1.02	0.310
ESRD No (ref)				
CKD Stage IIIb or higher Yes	−1.022	0.967	−1.06	0.290
CKD Stage IIIb or higher No (ref)				

BMI, body mass index; CCI, comprehensive complications index; COPD, chronic obstructive pulmonary disease; atrial fib, atrial fibrillation; ESRD, end-stage renal disease; CKD, chronic kidney disease.

4. Discussion

In a primarily Black patient population, BMI was an independent risk factor for COVID-19 intubation and an independent predictor of ICU LOS and intubation days. Consistent with previous reports, poorer outcomes were found in patients with moderate and severe obesity (BMI ≥35 kg/m^2) compared with normal weight.[2–4]

Our finding that BMI was not an independent risk factor for in-hospital COVID-19 mortality adds to previous studies reporting mixed results on the role of BMI in COVID-19 mortality. One meta-analysis of 22 studies (n = 12,591) reported that obesity was not associated with increased hospital mortality from COVID-19 (OR = 0.89, 95% CI [0.32−2.51]),[6] whereas another meta-analysis of 14 studies (n = 26,507)) found a relationship between BMI and mortality in patients with BMI >25kg/m^2 (OR 3.68, CI 1.54−8.83, p = 0.005).[7] Previous studies have reported a J-shaped curve associated with BMI and COVID-19 in-hospital mortality.[2–4] One report of a very large study group showed risk of COVID-19-related hospitalization, ICU admission, and death increasing sharply with more severe obesity in a primarily white population (63.7% whites, 18.4% blacks).[4] Another study found that severe obesity and age less than 60 years were associated with higher COVID-19 mortality in a largely Hispanic out-patient population (Hispanics 54.2%, 17.5% white, 8.4% black).[3] Our data show similar results in a primarily Black population.

One unexpected finding of our study was the relatively positive outcomes for patients with mild obesity (class I, 30.0−34.9 kg/m^2). These patients had the lowest odds ratio of in-hospital mortality compared to patients with normal BMI. Moderate obesity (class II, 35.0−39.9 kg/m^2) was associated with increased odds of intubation compared with normal weight, but mild

Table 8. Multivariate linear regression analysis controlling for all variables found that BMI was an independent predictor of intubation days ($p = 0.001$).

Parameter	Estimate	Standard Error	t Value	P value
BMI Underweight	−0.819	1.591	−0.51	0.607
BMI Overweight	1.679	0.582	2.89	0.004
BMI Class 1 obesity	0.801	0.663	1.21	0.227
BMI Class 2 obesity	2.461	0.750	3.28	0.001
BMI Class 3 obesity	2.583	0.758	3.41	0.001
BMI Normal (ref)				
Age	−0.012	0.021	−0.59	0.559
Sex Male	0.508	0.415	1.22	0.221
Sex Female (ref)				
Race Black	−0.323	0.607	−0.53	0.595
Race Other	−0.357	0.715	−0.50	0.618
Race White (ref)				
CCI	0.1464	0.153	0.95	0.340
COPD Yes	−0.862	0.739	−1.17	0.244
COPD No (ref)				
Coronary artery disease Yes	−0.177	0.680	−0.26	0.795
Coronary artery disease No (ref)				
Diabetes on insulin Yes	0.351	0.651	0.54	0.590
Diabetes on insulin No (ref)				
Diabetes not on insulin Yes	0.465	0.521	0.89	0.372
Diabetes not on insulin No (ref)				
Hypertension Yes	0.318	0.502	0.63	0.527
Hypertension No (ref)				
Atrial Fib or flutter Yes	−0.690	0.724	−0.95	0.341
Atrial Fib or flutter No (ref)				
Active cancer Yes	−0.488	1.187	−0.41	0.681
Active cancer No (ref)				
ESRD Yes	−0.576	0.831	−0.69	0.489
ESRD No (ref)				
CKD Stage IIIb or higher Yes	−1.031	0.782	−1.32	0.187
CKD Stage IIIb or higher No (ref)				

BMI, body mass index; CCI, comprehensive complications index; COPD, chronic obstructive pulmonary disease; atrial fib, atrial fibrillation; ESRD, end-stage renal disease; CKD, chronic kidney disease.

obesity was not. Significantly higher intubation days compared with normal weight patients was found in patients with overweight and with moderate and severe obesity, but not in patients with mild obesity, and patients with mild obesity had higher odds of being discharged to home compared with normal weight patients. These findings appeared to conflict with previous observations of a J-shaped curve for adverse COVID-19 outcomes. However, we believe our results may reflect the relatively older age and higher comorbidities in the underweight, normal weight, and overweight groups, factors that have been associated with poorer COVID-19 outcomes.[8,9] Age and comorbidities were comparable in patients in class I, II and III obesity, but the effects of moderate and severe obesity might have counteracted the advantage of fewer comorbidities in these groups, and the younger age observed in these groups has been reported as a risk factor for worse COVID-19 outcomes in more severe obesity.[3,10]

Limitations of this study include the single health system observational design. Resource limitations prevented the inclusion of all patients in the study period. The inclusion of all patients could have led to different results, but all patients were consecutive in discrete time spans within the study period and we applied strict inclusion criteria to ensure that the study population provided a strong foundation for any study conclusions. We had to exclude 458 charts that should not have appeared in the original data file because they did not meet our inclusion criteria. However, only 113 (9%) of the remaining charts were excluded for missing data. The senior author reviewed a percentage of charts for accuracy of abstraction, but misclassification by data abstractors could have occurred. The sample size for moderate and severe obesity was relatively small, which could have influenced the mortality findings. However, other significant findings were associated with patients in these weight categories. Finally, other possibly relevant factors, such as sleep apnea, were not considered in this report but could provide a direction for future study.

In a majority Black population and with consideration of comorbidities, BMI was an independent risk factor for COVID-19 intubation and an independent predictor of ICU LOS and intubation days. Moderate to severe obesity in this population was associated with significantly worse outcomes compared to patients in lower weight classes, as has been reported in populations with other racial distributions.

Conflict of interest

The authors have no conflict of interest in connection with this article.

References

1. Hales CM, Carroll MD, Fryar CD, Ogden CL. Prevalence of obesity and severe obesity among adults: United States, 2017-2018. *NCHS Data Brief*. 2020;(360):1−8.
2. Goyal P, Ringel JB, Rajan M, et al. Obesity and COVID-19 in New York city: a retrospective cohort study. *Ann Intern Med*. 2020;173(10):855−858. https://doi.org/10.7326/M20-2730.

3. 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(10):773–781. https://doi.org/10.7326/M20-3742.
4. 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(10):355–361. https://doi.org/10.15585/mmwr.mm7010e4. Published 2021 Mar 12.
5. Price-Haywood EG, Burton J, Fort D, Seoane L. Hospitalization and mortality among black patients and white patients with Covid-19. *N Engl J Med*. 2020;382(26):2534–2543. https://doi.org/10.1056/NEJMsa2011686.
6. Chu Y, Yang J, Shi J, Zhang P, Wang X. Obesity is associated with increased severity of disease in COVID-19 pneumonia: a systematic review and meta-analysis. *Eur J Med Res*. 2020;25(1):64. https://doi.org/10.1186/s40001-020-00464-9.
7. Hussain A, Mahawar K, Xia Z, Yang W, El-Hasani S. Obesity and mortality of COVID-19. Meta-analysis. *Obes Res Clin Pract*. 2020;14(4):295–300. https://doi.org/10.1016/j.orcp.2020.07.002.
8. Grasselli G, Zangrillo A, Zanella A, et al. Baseline characteristics and outcomes of 1591 patients infected with SARS-CoV-2 admitted to ICUs of the Lombardy region. *Italy. JAMA.* 2020;323(16):1574–1581. https://doi.org/10.1001/jama.2020.5394.
9. 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(2):e16–e25. https://doi.org/10.1016/j.jinf.2020.04.021.
10. Hendren NS, de Lemos JA, Ayers C, et al. Association of body mass index and age with morbidity and mortality in patients hospitalized with COVID-19: results from the American Heart Association COVID-19 Cardiovascular Disease Registry. *Circulation*. 2021;143(2):135–144. https://doi.org/10.1161/CIRCULATIONAHA.120.051936.