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## Body mass index and COVID-19 outcomes: A retrospective cross-sectional study at a tertiary care center in India

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### ABSTRACT

**Objective:** To determine the association between body weight and COVID-19 outcomes.

**Methods:** This is a retrospective cohort study of COVID-19 patients admitted in a dedicated COVID-19 hospital, a tertiary health care center, between May and June 2021. Demographic data and baseline variables, including age, sex, body mass index (BMI), and comorbidities were collected. Outcomes (death or mechanical ventilation) of the patients with different BMI, age, comorbidities, and qSOFA scores were compared. Besides, the risk factors for death or mechanical ventilation were determined.

**Results:** The mean age of the subjects was (51.8±14.7) years old, and 233 (74.2%) were male. There were 103 (32.8%) patients with normal weight, 143 (45.5%) patients were overweight, and 68 (21.7%) patients were obese. In-hospital deaths and need of mechanical ventilations were significantly higher in the obese and the overweight group compared to the normal weight group, in age group ≥65 years compared to <65 years, in patients with ≥1 comorbidities compared to patients without comorbidities, in patients with qSOFA scores ≥2 compared to patients with qSOFA scores <2. There was a significantly increased risk of death (*RR*: 4.1, 95% *CI* 1.0-17.4, *P*=0.04) and significantly increased need of mechanical ventilation (*RR*: 5.2, 95% *CI* 1.8-15.2, *P*=0.002) in the obese patients compared with those with normal weight after controlling other covariates.

**Conclusion:** Obesity is one of the significant risk factors for adverse outcomes in COVID-19 patients and should be considered during management.

**KEYWORDS:** Overweight; Obesity; Body mass index; COVID-19; Outcome

### 1. Introduction

Severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2), which causes Corona Virus Disease 2019 (COVID-19), was first detected in 2019 and swept rapidly to whole Globe. World health organization (WHO) had declared COVID-19 a pandemic in March 2020[1]. First case of COVID-19 infection was identified on January 30, 2020 in India[2]. Most people with COVID-19 have mild illnesses or are asymptomatic. Approximately 14% require hospitalization and oxygen therapy, and 5% patients require admission in critical care unit[3].

Obesity has been shown to be associated with severe diseases and poor outcomes in COVID-19 patients[4]. In India more than 135 million individuals are affected with obesity with prevalence of

#### Significance

Obesity has been shown to be associated with severity and outcomes of in COVID-19. Our study shows that overweight and obesity are risk factors of adverse in COVID-19 patients. Furthermore, old age, male gender, presence of comorbidities and higher qSOFA score were also significantly associated with a worse outcome in COVID-19 patients.

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1.8%-31.3%[5]. Various studies have shown that obesity is associated with poor outcome in COVID-19 patients, such as increased hospitalizations, severe pneumonia, and mechanical ventilation[4,6,7]. Various potential mechanisms involved in severity of COVID-19 due to obesity are restrictive lung disease, reduction in cardiorespiratory reserve, lipotoxicity, and potentiation of the immune dysregulation[8].

There are limited studies from India showing the association between obesity and poor outcome in COVID-19. This study is designed to determine the association between body mass index (BMI) and COVID-19 outcomes in a dedicated COVID-19 hospital, at a tertiary care center, in Rajasthan, India.

## 2. Patients and methods

### 2.1. Study design and setting

This is a retrospective cross-sectional cohort study, including reverse-transcription polymerase chain reaction (RT-PCR) confirmed COVID-19 patients hospitalized in tertiary care center of northwest Rajasthan, during May-June 2021. Clinical data including the vital signs on admission, associated comorbid conditions, and outcome were collected.

### 2.2. Sample size and ethical approval

Sample size was calculated by formula,  $n=4pq/L^2$  ( $p$ : Prevalence;  $q$ : 100  $p$ ;  $L$ : Permissible error). Presuming a frequency of 50% sample

size was 110 taking a permissible error of 20%.

### 2.3. Ethical approval

Institutional Review Board of Sardar Patel Medical College, Bikaner (Rajasthan) India approved the study [No: F. 29 (Acad) SPMC/2021/1556]. Written informed consent was obtained from each study subject.

### 2.4. Subjects

The study population included RT-PCR (nasopharyngeal swab) confirmed adult COVID-19 patients aged  $\geq 18$  years, who were admitted during May-June 2021. Underweight patients (defined as a BMI  $< 18.50$  kg/m<sup>2</sup>) and patients whose BMI was not recorded were excluded from the study (Figure 1).

### 2.5. Primary predictors

BMI was calculated by formula weight (kilograms)/height (meters)<sup>2</sup>. Patients were divided into three categories: normal weight (BMI: 18.50-22.99 kg/m<sup>2</sup>), overweight (BMI: 23.00-27.49 kg/m<sup>2</sup>), and obese (BMI:  $\geq 27.50$  kg/m<sup>2</sup>)[9].

### 2.6. Covariables

Covariables were age, sex, comorbidities ( $\geq 1$ ), diabetes mellitus, and the quick sequential organ failure assessment (qSOFA) score

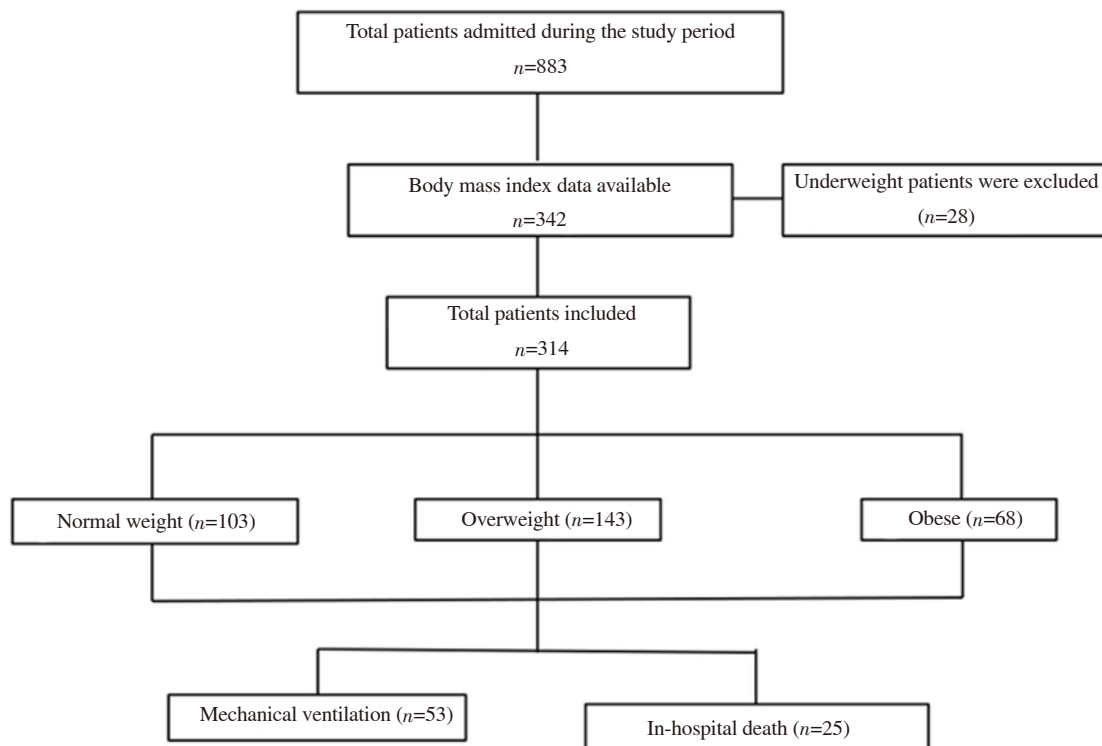


Figure 1. The study flowchart.

at time of admission. qSOFA was calculated by using 1 point for each of the following criteria: tachypnea (respiratory rate  $\geq 22$ /min), hypotension (systolic blood pressure  $\leq 100$  mmHg), and altered sensorium with Glasgow Coma Scale (GCS)  $< 15$ . qSOFA scores were bifurcated at a cut-off of 2 as scores of  $\geq 2$  is associated with higher risk of mortality<sup>[10]</sup>. Data self-reported by the patient were recorded in bedhead ticket by the health care person.

## 2.7. Outcomes

The primary outcome is the relation of BMI and the need of mechanical ventilation and hospital death. The secondary outcome is the relation of age, sex, comorbidities, qSOFA scores and the need of mechanical ventilation and in-hospital death.

## 2.8. Statistical analysis

The data were analyzed using SPSS 16.0 software. Continuous and categorical data were presented as mean with standard deviation and number (proportion) respectively. Outcome of the patients with different bodyweight, age, comorbidities, and qSOFA scores were compared by *Chi* square test. Binary logistic regression was done to determine whether any of the BMI groups was associated with an increase in the relative risk of outcomes upon adjustment for covariables.

## 3. Results

The characteristics of the study participants are represented in Table 1. The mean age of the subjects was  $(51.8 \pm 14.7)$  years old, with most of the patients 244 (77.7%)  $< 65$  years old. In this study, 233 (74.2%) were male. Diabetes mellitus ( $n=64$ , 20.4%) and hypertension ( $n=57$ , 18.2%) were the most common comorbidities, and 101 (32.2%) patients had  $\geq 1$  comorbidities. Out of 314 patients, 103 (32.8%) had normal weight, 143 (45.5%) were overweight, and 68 (21.7%) were obese (Table 1).

In-hospital deaths were significantly more in the obese and the overweight group compared to the normal weight group ( $P=0.02$ ), in age group  $\geq 65$  years compared to  $< 65$  years ( $P<0.001$ ), in patients with  $\geq 1$  comorbidities compared to patients without comorbidities ( $P<0.001$ ), in patients with qSOFA scores  $\geq 2$  compared to patients with qSOFA scores  $< 2$  ( $P<0.001$ ). Likewise, need of mechanical ventilations were significantly higher in obese and overweight groups compared to the normal weight group ( $P<0.001$ ), in age group  $\geq 65$  years compared to  $< 65$  years ( $P<0.001$ ), in patients with  $\geq 1$  comorbidities compared to patients without comorbidities ( $P<0.001$ ), in patients with qSOFA scores  $\geq 2$  compared to patients with qSOFA scores  $< 2$  ( $P<0.001$ ) (Table 2).

**Table 1.** Patients characteristics.

Parameters	n(%)
<b>Age, years</b>	-
<65	244 (77.7)
$\geq 65$	70 (22.3)
<b>Sex</b>	-
Male	233 (74.2)
Female	81 (25.8)
<b>Body weight*</b>	-
Normal	103 (32.8)
Overweight	143 (45.5)
Obese	68 (21.7)
<b>Comorbidities</b>	-
Diabetes	64 (20.4)
Hypertension	57 (18.2)
COPD	4 (1.3)
Coronary artery disease	15 (4.8)
Chronic kidney disease	6 (1.9)
Chronic liver disease	6 (1.9)
$\geq 1$ comorbidities	101 (32.2)

\*: normal weight denotes BMI: 18.50-22.99 kg/m<sup>2</sup>, overweight BMI: 23.00-27.49 kg/m<sup>2</sup>, and obese BMI:  $\geq 27.50$  kg/m<sup>2</sup>; COPD: chronic obstructive pulmonary disease.

**Table 2.** Outcome of patients with different bodyweight, age, comorbidities, and qSOFA scores.

Parameters	Mechanical ventilation	In-hospital death
<b>Body weight, n(%)</b>	-	-
Normal weight	7 (6.8)	3 (2.9)
Overweight	24 (16.8)	12 (8.3)
Obese	22 (32.4)	10 (14.7)
$\chi^2$	19.1	7.84
<i>P</i>	$< 0.001^*$	0.02*
<b>Age, years, n(%)</b>	-	-
$\geq 65$	29 (41.4)	14 (20.0)
<65	24 (9.8)	11 (4.5)
$\chi^2$	38.7	17.8
<i>P</i>	$< 0.001^*$	$< 0.001^*$
<b>Comorbidities, n(%)</b>	-	-
$\geq 1$	36 (35.6)	19 (18.8)
<1	17 (7.9)	6 (2.8)
$\chi^2$	37.4	23.9
<i>P</i>	$< 0.001^*$	$< 0.001^*$
<b>qSOFA, n(%)</b>	-	-
$\geq 2$	9 (64.3)	5 (35.7)
<2	44 (14.7)	20 (6.7)
$\chi^2$	23.5	15.4
<i>P</i>	$< 0.001^*$	$< 0.001^*$

Normal weight denotes BMI: 18.50-22.99 kg/m<sup>2</sup>, overweight BMI: 23.00-27.49 kg/m<sup>2</sup>, and obese BMI:  $\geq 27.50$  kg/m<sup>2</sup>; qSOFA: Quick sequential organ failure assessment; \*: Statistically significant.

After controlling all covariables, there was a statistically significant increased risk of death [relative risk (RR): 4.1, 95% CI 1.0-17.4,  $P=0.04$ ] and need of mechanical ventilation (RR 5.2, 95% CI 1.8-15.2,  $P=0.002$ ) in the obese patients compared with those with normal weight (Table 2). Likewise, there was a statistically significant increased RR of death in the patients with age  $\geq 65$  years (RR 2.7, 95% CI 1.1-6.9,  $P=0.03$ ) in comparison to patients with age  $< 65$  years, patients with presence of  $\geq 1$  comorbidities (RR 4.4, 95% CI 1.1-17.6,  $P=0.03$ ) compared with patients without

**Table 3.** Binary logistic regression analysis for outcome of hospital death and mechanical ventilation between body mass index categories.

Predictors	In-hospital death		Mechanical ventilation	
	Relative risk (95% CI)	P	Relative risk (95% CI)	P
<b>Body mass index</b>	-	-	-	-
Overweight	2.4 (0.6-9.8)	0.21	2.2 (0.8-6.2)	0.110
Obese	4.1 (1.0-17.4)	0.04*	5.2 (1.8-15.2)	0.002*
Normal weight	Reference	-	Reference	-
<b>Sex</b>	-	-	-	-
Male	2.2 (0.6-7.4)	0.20	2.5 (1.0-6.47)	0.050
Female	Reference	-	Reference	-
<b>Age</b>	-	-	-	-
≥65	2.7 (1.1-6.9)	0.03*	4.4 (2.1-9.2)	<0.001*
<65	Reference	-	Reference	-
<b>Comorbidities</b>	-	-	-	-
≥1	4.4 (1.1-17.6)	0.03*	3.7 (1.3-10.8)	0.010*
<1	Reference	-	Reference	-
<b>qSOFA scores</b>	-	-	-	-
≥2	4.9 (1.2-20.7)	0.02*	8.7 (2.1-36.3)	0.003*
<2	Reference	-	Reference	-

Normal weight denotes BMI: 18.50-22.99 kg/m<sup>2</sup>, overweight BMI: 23.00-27.49 kg/m<sup>2</sup>, and obese BMI: ≥27.50 kg/m<sup>2</sup>; qSOFA: Quick sequential organ failure assessment; \*: Statistically significant.

comorbidities, and patients with qSOFA scores ≥2 (RR 4.9, 95% CI 1.2–20.7, P=0.02) compared with patients with qSOFA scores <2. Furthermore, there was a statistically significant increased RR of a requirement of mechanical ventilation in the patients with age ≥65 years (RR: 4.4, 95% CI 2.1-9.2, P<0.001) compared with patients age <65 years, patients with presence of ≥1 comorbidities (RR: 3.7, 95% CI: 1.3-10.8, P=0.01) compared with patients without comorbidities, and patients with qSOFA scores ≥2 (RR: 8.7, 95% CI 2.1-36.3, P=0.003) compared with patients with qSOFA scores <2 (Table 3).

#### 4. Discussion

In this study hospital deaths and need of mechanical ventilations were significantly higher in the obese and the overweight group compared to the normal weight group, in age group ≥65 years compared to <65 years, in patients with ≥1 comorbidities compared to patients without comorbidities, in patients with qSOFA scores ≥2 compared to patients with qSOFA scores <2. Obesity is independently associated with adverse outcomes in patients with COVID-19 after controlling for age, gender, comorbidities (≥1), and qSOFA score. Obese patients had an increased probability of hospital death (RR: 4.1, 95% CI 1.0-17.4, P=0.04) and a need of mechanical ventilation (RR: 5.2, 95% CI 1.8-15.2, P=0.002) compared to the patients with normal weight. Obesity has been reported an important risk factor for hospitalization and poor outcomes in COVID-19 patients in previous studies[11-14].

Nakeshbandi *et al.* reported higher risk of mortality (RR: 1.3, 95% CI 1.0-1.7) and intubation (RR: 2.4, 95% CI 1.5-4.0) in the obese groups compared with those with normal weight in patients with COVID-19 after controlling for age, gender, diabetes, hypertension, and qSOFA score[11]. Hendren *et al.* reported that obese and particularly young (age ≤50 years) patients had more hospital death or requirement of

mechanical ventilation[12]. Suresh *et al.* reported that obese COVID-19 patients had more risk of ICU admission (OR: 1.37, 95% CI 1.07-1.76; P=0.012) and requirement of intubation (OR: 1.37, 95% CI 1.04-1.80; P=0.026)[15].

The mechanism of this association is not clearly known but may be due to obesity induced proinflammatory state, lipo-toxicity and reduction in cardiorespiratory reserve[8]. Obesity is part of metabolic syndrome which includes diabetes and hypertension, which are associated with poor outcomes in COVID-19 patients[16]. Besides this, SARS-CoV-2 has a high affinity for angiotensin-converting enzyme 2, which is highly expressed in adipose tissue, and therefore obesity exacerbates the severity of COVID-19[17]. Furthermore, obesity is associated with decreased functional capacity, pulmonary expiratory reserve volume, and lung compliance, which may contribute to the severity of COVID-19[18]. Obese patients with influenza have also shown to be associated with more risk of hospitalization and death, and a prolonged need of mechanical ventilation than normal weight patients [19].

There was significantly increased risk of hospital death and requirement of mechanical ventilation in the patients with age ≥65 years, patients having one or more comorbidities, and patients with qSOFA score two or more. Contrary to this other previous studies have reported that younger patients with obesity had adverse outcome in COVID-19 infection[11,12,20]. Bhargava *et al.* reported that after multivariable regression analysis, factors associated with an increased risk of hospital death were age more than 60 years and higher qSOFA scores on admission[21]. A study from China also reported that older age and higher SOFA scores at the time of admission were associated with a higher risk of hospital death[16]. The qSOFA score was proposed by Third International Consensus Definitions for Sepsis and Septic Shock task force and it has a higher prognostic value for hospital death[22]. A recent meta-analysis also revealed that COVID-19 patients with male gender, old age and comorbidities were associated with

adverse outcome<sup>[23]</sup>. Liu *et al.* reported that qSOFA scores at admission are an accepted and effective predictor for in-hospital mortality in critically ill COVID-19 patients<sup>[24]</sup>. Besides this, a retrospective study from Spain concluded that elderly hospitalized COVID-19 patients had increased risk of in-hospital death even without comorbidities<sup>[25]</sup>. Zhou *et al.* reported that on multivariable regression there was an increasing odd of mortality with older age, higher SOFA scores on admission<sup>[16]</sup>. A study from Canada found that presence of comorbidities is a strong predictor for mortality and adverse outcomes among COVID-19 patients even in younger individuals<sup>[26]</sup>.

This study has few limitations. As this study is retrospective in nature, potential for bias due to unmeasured confounding factors is unavoidable. In-hospital death and requirement of mechanical ventilation may be influenced by other factors. Also, our study is hospital based and may not be representative of the whole population.

To conclude, present study strengthens the hypothesis that overweight and obesity is an important risk factor for adverse outcome in COVID-19 patients. Besides old age, presence of comorbidities and higher qSOFA scores were also significantly associated with poor outcome in COVID-19 patients. Knowledge of these risk factors may help physician to recognize and intervene the high-risk patients earliest to prevent morbidity and mortality. Further research should be done to find out comorbidities and risk factors responsible for adverse outcome in COVID-19 patients.

### Conflict of interest statement

The authors report no conflict of interest.

### Authors' contributions

H.R.N. contributed in the project design, data interpretation, drafting the article, revising it critically; and final approval of the version to be published; S.K. and R.K. contributed to project design, data interpretation, statistical analysis, article preparing and submission; A.S., K.K. and P.S. contributed to the collection of data, statistical analysis and data interpretation. All authors contributed equally to the final version of the manuscript.

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