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Cross-sectional Study

Obesity implications on SARS-CoV-2 infections' prevalence, hospitalizations, critical care needs, fatalities & vaccination rates: A public health crisis

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Coronavirus disease 2019 (COVID-19) has appropriately become the focus of attention and claimed the lives of 757,663 Americans as of November 12, 2021 [1]. Several comorbidities including hypertension, diabetes, cardiovascular disease, respiratory system disease, and obesity significantly increase the risk of severe COVID-19 infection [2,3]. Obesity, defined as a body mass index (BMI) $\geq$30 kg/m^2, affected 42.4% of adults and 19.3% of children from 2017 to 2018 and continues to rise in the United States (US) [4,5]. Currently, obesity is known to be a risk factor for death and intubation among other complications in those who are diagnosed with COVID-19 [6,7].

According to a Morbidity and Mortality Weekly Report assessing COVID-19 infections from December–March 2020, the majority of COVID-19 infections were among patients who were obese, despite this cohort comprising less than half of the overall study population (Table 1) [8]. Additionally, COVID-19 patients with a BMI $\geq$30 kg/m^2 comprised the majority of patients who were hospitalized (Fig. 1), admitted to the intensive care unit (ICU) or underwent invasive mechanical ventilation (IMV) measures (Fig. 2), and suffered in-hospital deaths (Fig. 3) [8]. Evidently, patients who are obese represent a high-risk group for severe COVID-19 illness and may warrant additional consideration for targeted interventions.

Given the aforementioned data, the prevalence of obesity in COVID-19 patients is a topic of heightened interest. Deep into the pandemic, a meta analysis was conducted which showed that persons who are obese carry an increased risk for testing positive for COVID-19, being hospitalized, and even dying [9]. Another study performed in the United Kingdom (UK) found that BMI and waist circumference were both associated with a dose-dependent increase in the odds of returning a positive COVID-19 test when compared to people with BMIs between 18 and <25 kg/m^2 [10]. Not only is there evidence for a higher prevalence of COVID-19 in patients who are obese, but also for disease complications upon infection. A systematic review and meta analysis performed by *Helvaci* et al. found an increased risk of hospitalization, ICU admission, and IMV requirements in COVID-19 patients who are obese in the US as well as Europe [11]. Furthermore, *Helvaci* et al. found that the prevalence of patients who are obese with COVID-19 requiring IMV surpassed the baseline prevalence of obesity in the US overall [11]. These results suggest that those with high BMIs require more resources such as IMV and may be a population subset with increased risk of severe COVID-19 illness.

Several mechanisms driving obesity as a risk factor for severe COVID-19 illness have been proposed. For example, excess abdominal weight in individuals who are obese impairs adequate ventilation and increases the risk for infection [7]. Additionally, it has been previously reported that there is significantly increased difficulty in ventilating patients who are obese via both mask ventilation and intubation [12,

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Table 1
Percentage of total patients in database for various BMI ranges compared to the Percentage of patients with COVID-19 infection for various BMI ranges. The percentage of patients in the obese BMI range with COVID-19 was greater than the percentage of patients with obese BMI in the database overall.

Comparison of Total Patients in Database to Patients with COVID-19 According to BMI		
BMI	Patients in Database N (%)	Patients with COVID-19 infection N (%)
<18.5 (Underweight)	79,988 (3%)	2674 (2%)
18.5–24.9 (Healthy Weight)	829,474 (26%)	28,349 (19%)
25–29.9 (Overweight)	936,132 (29%)	41,973 (28%)
≥30 (Obesity)	1,397,055 (43%)	75,498 (51%)

Source: Centers for Disease Control and Prevention. (2021, March 12). Body Mass Index and Risk for COVID-19–Related Hospitalization, Intensive Care Unit Admission, Invasive Mechanical Ventilation, and Death — United States, March–December 2020 https://www.cdc.gov/mmwr/volumes/70/wr/mm7010e4.htm#F1_down. Accessed August 22nd, 2021.

13]. The increased thoracic mass may necessitate the use of higher positive end-expiratory peak pressures to maintain proper oxygenation [14]. Consequently, there is an increased risk of barotrauma such as pneumothorax and alveolar rupture [15]. Moreover, the increased expression of angiotensin-converting enzyme 2 (ACE2) receptors, a known functional host-cell receptor used by the SARS-CoV-2 virus to invade hosts, in individuals who are obese may play a role in their increased rate of infection [7].

Persons with obese BMIs also suffer from immune system dysfunction and chronic inflammation which may impair their ability to fight infection [16,17]. When COVID-19 vaccines were initially rolled out to the public, the Advisory Committee on Immunization Practices (ACIP) included obesity as a qualifier for eligibility in Phase 1c of the COVID-19 vaccine allocations [17]. However, there is hesitation due to safety concerns and alleged decreased immunologic efficacy in this population [18]. Fortunately, COVID-19 vaccines show promising efficacy in various populations while COVID-19 trials do not demonstrate a difference in vaccine efficacy among normal and obese BMI cohorts [19,20]. Thus, advocating for increased vaccination among obese patients may be an avenue worth considering to mitigate the increased risk of severe COVID-19 complications among obese patients [20].

Furthermore, there is evidence suggesting that >94% of COVID-19 cases occur among those who are unvaccinated and persons of increased BMI are at increased risk for severe disease outcomes. Misinformation regarding COVID-19 vaccination reaching obese individuals is of utmost concern [18,21]. Aggressive counseling and resolution of misinformation may result in increased vaccination rates among the obese population and may add an extra layer of protection for those particularly vulnerable to severe COVID-19 illness [21].

Finally, social factors may contribute to the worsened outcomes for overweight patients. First, the attention devoted to the COVID-19 virus overshadows other prevalent, chronic diseases that carry increased risk for severe COVID-19 complications [22]. For example, the nationwide stay at home mandates facilitated and exacerbated unhealthy lifestyles and increased the prevalence of obesity during the pandemic [23–25]. A retrospective cohort study of 1,958,638 individuals predicted that 3 month periods of lockdown would result in over one third of individuals moving into the next BMI category within the obese range due to overall reductions in physical activity during the pandemic [26–28]. Thus, public health efforts directed towards an increase in physical activity are crucial in both children and adults due to benefits of enhancing immune function, creating a more robust response to vaccinations, and improving disease outcomes [29]. A recent study showed that adults who met physical activity guidelines had lower odds of hospitalizations, ICU admissions, and death from COVID-19 even after adjusting for comorbid conditions [30]. Furthermore, physical activity has also been shown to improve stress tolerance and decrease the levels of circulating cortisol [31]. While several public campaigns have been launched, such as the #healthyathome initiative by the World Health Organization, it is essential that we continue to increase awareness and promote their importance [32]. Given the uncertainty of the impact of the new coronavirus variant cases and disparities in vaccination rates among states, it is our responsibility to improve the aspects of our physical health that we can control [21].

The COVID-19 pandemic has inflicted substantial burdens on a global scale. Several conditions are known to be risk factors for developing severe COVID-19 illness and are particularly prevalent among patients who are obese. Patients in the obese BMI category exhibit the majority of hospitalizations, ICU admissions, and deaths due to COVID-19 despite comprising less than half of the overall population. Directing

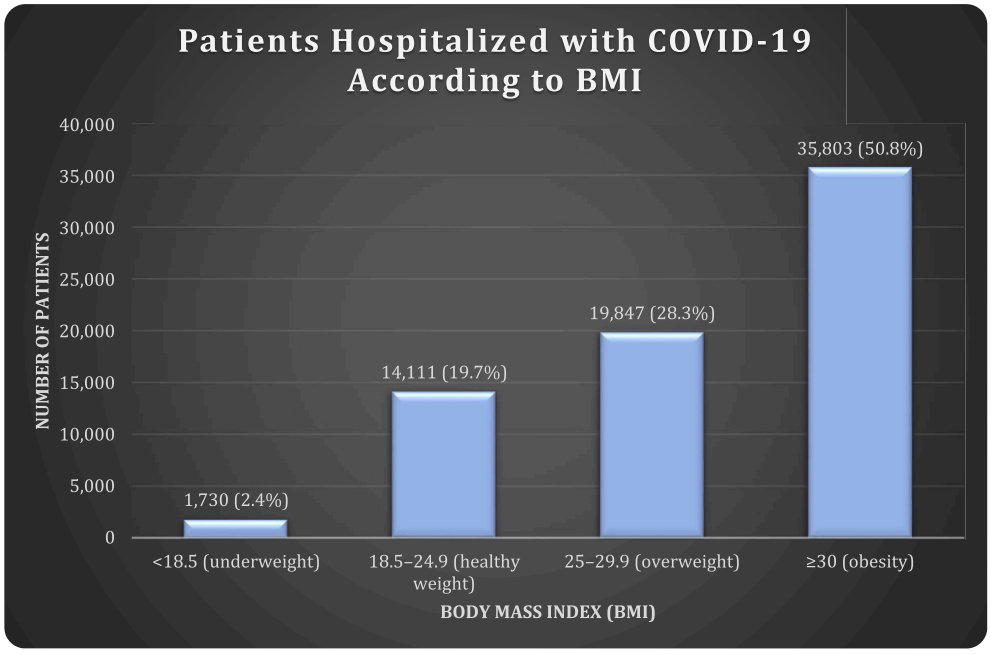

Fig. 1. Number of patients hospitalized with COVID-19 for various BMI ranges. The largest number of COVID-19 hospitalizations was seen in the obese BMI category.
Source: Centers for Disease Control and Prevention. (2021, March 12). Body Mass Index and Risk for COVID-19–Related Hospitalization, Intensive Care Unit Admission, Invasive Mechanical Ventilation, and Death — United States, March–December 2020 https://www.cdc.gov/mmwr/volumes/70/wr/mm7010e4.htm#F1_down. Accessed August 22nd, 2021

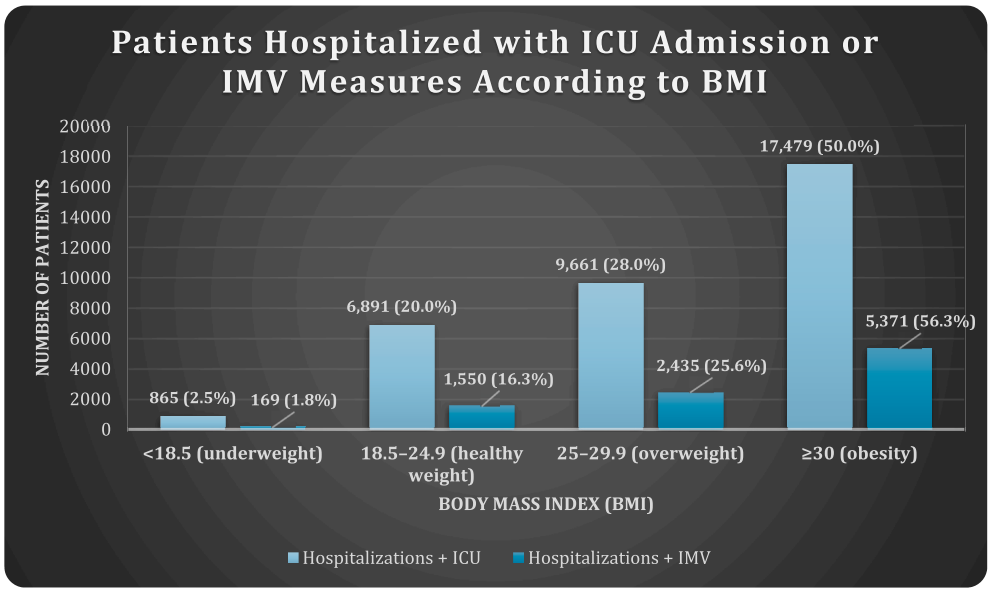

Fig. 2. Number of patients hospitalized with COVID-19 who underwent ICU admission of IMV for various BMI ranges.
The largest number of COVID-19 ICU admissions and IMV use was seen in the obese BMI category.
Source: Centers for Disease Control and Prevention. (2021, March 12). Body Mass Index and Risk for COVID-19–RelatedHospitalization, Intensive Care Unit Admission, Invasive Mechanical Ventilation, and Death — United States, March–December 2020 https://www.cdc.gov/mmwr/volumes/70/wr/mm7010e4.htm#F1_down. Accessed August 22nd, 2021

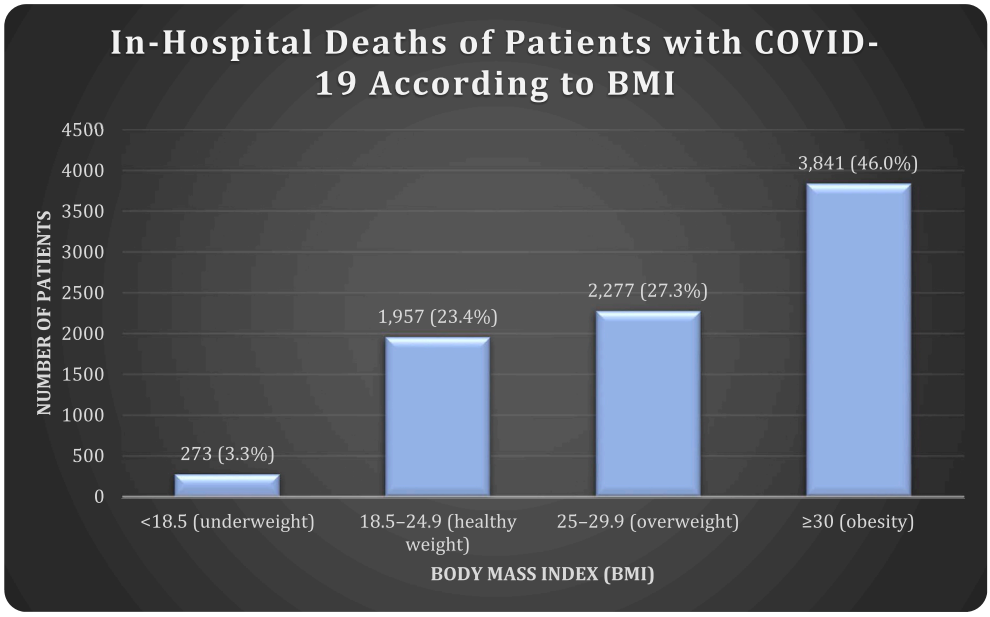

Fig. 3. Number of in-hospital deaths in patients with COVID-19 for various BMI ranges. The largest number of COVID-19 in-hospital deaths was seen in the obese BMI category.
Source: Centers for Disease Control and Prevention. (2021, March 12). Body Mass Index and Risk for COVID-19–Related Hospitalization, Intensive Care Unit Admission, Invasive Mechanical Ventilation, and Death — United States, March–December 2020 https://www.cdc.gov/mmwr/volumes/70/wr/mm7010e4.htm#F1_down. Accessed August 22nd, 2021

efforts aimed to increase vaccination rates and lifestyle modifications particularly among individuals who are obese are realistic solutions to consider in order to proactively counteract the increased risk posed to both adults and children.

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Author contribution

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None.

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