The International Young Researchers' Conference
DOI: 10.34614/iyrc2021f14

Association Between BMI and COVID-19 Clinical Outcome Severity: A Systematic Review Comparing Data from Asian and Western Countries

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Abstract

Given the global significance of COVID-19, it is crucial to discuss potential factors that correlate with the severity of clinical outcomes for patients. This study examines the association between obesity, characterized by high BMI, and increased severity of adverse clinical outcomes for COVID-19 patients, quantified through ICU admission numbers. A total of 20 studies between 2020 and 2021 from both Western countries and Asian countries were systematically reviewed, and data regarding the nature of the study, number of patients in various BMI groups, and ICU admissions were extracted. The studies were found in a medical research database (PubMed) and qualitatively screened to determine their relevance. The correlation between obesity and ICU admissions was then calculated, ensuring that two distinct correlation values were determined: one for the Western-centric studies and one for the Asian-centric studies. The former showed a stronger positive correlation. Given that obesity may serve as an indicator for severe clinical outcomes, this research can be used in relevant geographical locations for the betterment and increased caution of patient care.

Keywords: COVID-19, Body Mass Index (BMI), Obesity, Clinical Outcome Severity, Intensive Care Unit (ICU)

Introduction

In January of 2020, the World Health Organization established an outbreak of "a novel coronavirus" (World Health Organization, n.d.). Over the span of almost two years, the source of the infection, SARS-CoV-2, has caused over 216 million cases, and over 4 million deaths (Google News, n.d.).

Given the broad range of manners by which this infection can manifest in different patients, it is crucial to establish the influence of various prognostic factors that contribute to the potential severity of their clinical outcomes (Földi et al., 2020). This will therefore allow both physicians and patients to gain an invaluable insight into developing improved and potentially earlier treatment of the disease. Several diseases have been previously recognized as factors correlating with adverse clinical outcomes in COVID-19 patients, such as diabetes and cardiovascular diseases. Given that such diseases often have relations with excess body fat, obesity may be another risk factor predisposing adverse clinical outcomes. Several sources have already concluded that obesity can be strongly associated with the severity of COVID-19, for reasons that will be discussed later in this review (Klang et al., 2020) (Giacomelli et al., 2020).

Despite this, there is a lack of literature investigating the direct relationship between obesity and ICU admissions rates, to demonstrate the severity of the patient's condition given this specific biological characteristic. This is especially

true in the case of comparing said relationship for patients across different geographical locations, despite the fact that ethnic variations in BMI classes exist. (The World Obesity Federation, n.d.) As such, this systematic review will compare the association between obesity and ICU admissions rates in studies focused on Asian subjects and Western subjects.

Methodology

Search Strategy

A systematic search was performed through a scientific database, namely PubMed, in search for studies between the years 2020 and 2021, as this is the ongoing period of the COVID-19's impact globally. Specific search terms were used with a filter to ensure all results were of open-access journal articles. The following search key was used: ((covid 19) OR (coronavirus) OR (SARS-cov-2)) AND (BMI), thereby combining various iterations of COVID-19, whilst leaving a broader scope for BMI related results.

Selection and Eligibility Criteria

After using a reference manager (Zotero) to remove duplicates of the journal articles found, the titles and abstracts of the remaining articles were screened following a rigid selection and eligibility criteria. The following inclusion criteria were used:

1. Journal articles written in English
2. Journal articles reporting BMI classes of hospitalized patients with confirmed SARS-cov-2 infections
3. Journals reporting each BMI class's respective ICU admit rate as an indicator of the severity of the patient's condition
4. Patients were all adults above the age of 18
5. Prospective or retrospective cohort studies
6. BMI classes adhered to the following distinctions, as established by the World Obesity Federation (n.d.):
    a. Asian countries/patients: BMI ≥ 24.0 = Obese
    b. Western countries/patients: BMI ≥ 30.0 = Obese

The following exclusion criteria were used:

1. Review articles, letters and commentaries were to be rejected
2. Duplicate studies were to be rejected
3. Studies involving patients that have conditions significantly impacting their BMI were rejected (e.g. studies focused on pregnant women, pediatric patients, etc.)

Data Extraction

Data extracted from the remaining eligible studies were organized on a spreadsheet using Microsoft Excel. The following data were extracted from each included study:

1. Author(s)
2. Title
3. Publication Date
4. Digital Object Identifier (DOI)
5. Study Design
6. Study Location
7. Study Population
8. Population Age Range
9. Total Number of Intensive Care Unit (ICU) Admissions/Critical Condition Patients
10. Total number of patients in the non-Obese category
11. Total number of ICU/Critical Condition Patients in the non-Obese category
12. Total number of patients in the Obese category
13. Total number of ICU/Critical Condition Patients in the Obese category

BMI Category Classification

As mentioned previously, BMI categories were defined using pre-established guidelines by the World Obesity Federation (n.d.). The obesity category's values for Western and Asian patients were BMI ≥ 30.0 and BMI ≥ 24.0 respectively.

Results

PRISMA Flow Diagram

Figure 1 below shows a diagram of the study selection process in detail. A total of 736 sources were found from the initial search, of which 604 were excluded after assessing whether their titles and abstracts demonstrated any relevance to the focus of this research. Then, the remaining 132 articles were evaluated, adhering to the aforementioned selection and exclusion criteria. A total of 20 studies were finally selected and included for this systematic review. 17 of them were found to be Western-centric, and 3, Asian.

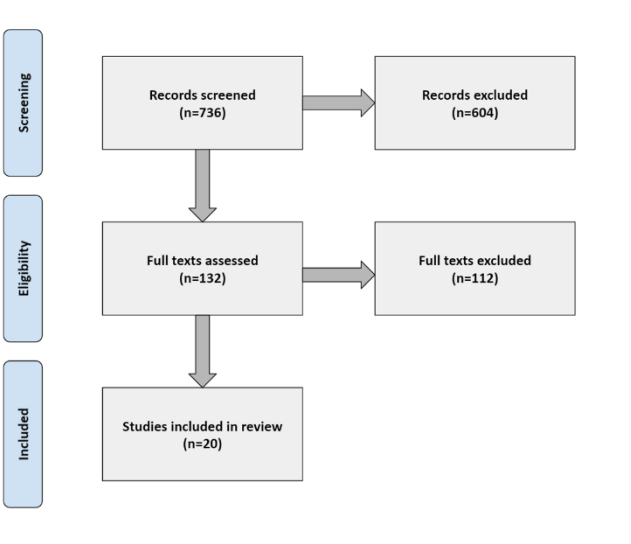

FIGURE 1: PRISMA Flow Diagram showing the screening process for eligible studies used in the research

Raw Data

After gathering the raw data needed to conduct this systematic review, basic statistical analysis was carried out using the information retrieved.

This data generally establishes that there are a greater proportion of patients with BMIs resulting in obesity that were admitted to the ICU, or considered patients of critical condition. Majority of these studies were conducted in the United States (n=8), with other European countries including Italy and France. The two Asian regions that were included were China and South Korea.

Statistical analysis

In the first section of this statistical analysis, it is crucial to establish whether a higher proportion of the obese patients in each study's population were admitted to the ICU compared to non-obese patients. To do this, the number of obese ICU patients were found as a fraction of the total number of obese patients, and compared to the proportion of non-obese patients in the ICU.

Out of the 20 studies included, the vast majority of them showed a greater proportion of obese patients in the ICU compared to non-obese patients (n=16). There were two studies in which there was a greater proportion of non-obese patients in the ICU than obese patients, however, the difference between the two were not substantial. Two studies showed included only ICU patients within their cohort populations, and therefore were not included in this comparison.

In order to determine the association between obesity and ICU admissions rates, the number of obese ICU patients as a percentage of the total number of obese patients was graphed against the ICU admission numbers as a percentage of each study's population. These were placed on a scatter plot, and the correlation between the two were found, for both Asia-based studies and Western-based studies. The scatter plots can be seen in Figures 2 and 3 below.

When calculating the correlation values for each scatter plot, the following equation was used:

$$r = \frac{\sum(x-\bar{x})(y-\bar{y})}{\sqrt{\sum(x-\bar{x})^2(y-\bar{y})^2}}$$

$$where\ r = correlation\ coefficient$$

$$x = \frac{number\ of\ obese\ ICU\ patients}{total\ number\ of\ obese\ patients}\ values\ in\ the\ sample$$

$$\bar{x} = mean\ of\ the \frac{number\ of\ obese\ ICU\ patients}{total\ number\ of\ obese\ patients}\ values\ in\ the\ sample$$

$$y = \frac{total\ ICU\ admissions}{total\ population\ of\ study}\ values\ in\ the\ sample$$

$$\bar{y} = mean\ of\ the \frac{total\ ICU\ admissions}{total\ population\ of\ study}\ values\ in\ the\ sample$$

The following results were obtained:

Figure 2	Figure 3
r=0.9907	r=0.5980

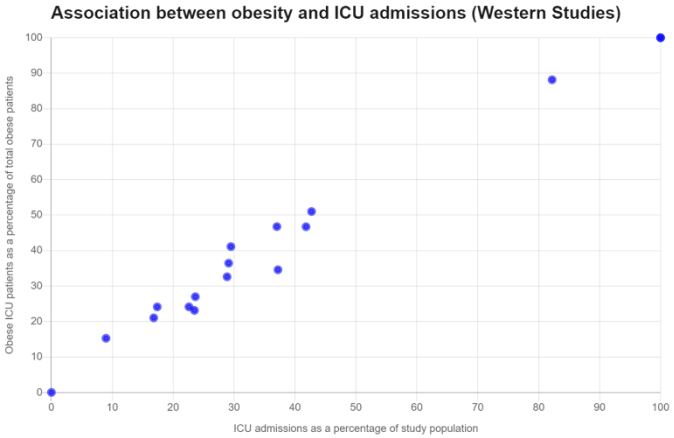

FIGURE 2: Association between obesity and ICU admissions (Western Studies)

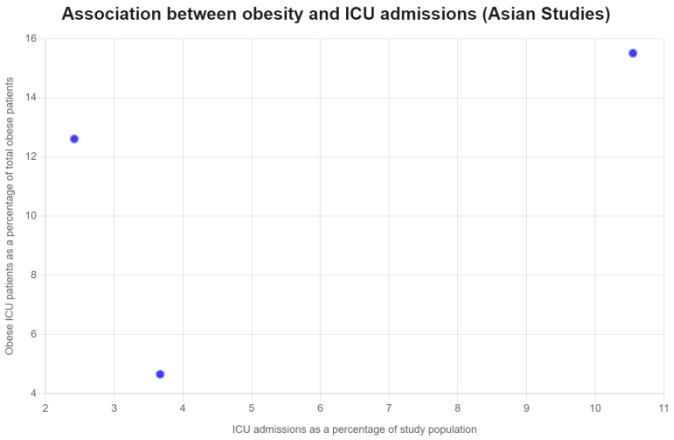

FIGURE 3: Association between obesity and ICU admissions (Asian Studies)

It can be seen that there was a much stronger positive correlation between the two variables for the Western-centric studies, with the difference being 0.3927. The strong positive correlation between the two variables for the Western centric studies is consistent with previous research establishing the increased incidence of adverse clinical outcomes given that a patient is obese (Pranata et al., 2021). Regarding the correlation figure for the three Asian-centric studies, given that there were an extremely limited number of studies centered around Asian patients, the correlation for Figure 3 most likely is not representative of the true relationship between the two variables. The figure, however, still demonstrates a positive correlation between the two variables.

Discussion

Obesity and ICU Admission

Several studies have explored the relationship between obesity and increased severity of adverse clinical outcomes in general, including increased probability of ICU admission. One highlighted that COVID-19 patients, common comorbidities include hypertension, diabetes, and cardiovascular issues in general, all of which relate to obesity, specifically through pathways in the renin-angiotensin system (a hormone system that regulates blood pressure and fluid balance in the body) (Földi et al., 2020) (TeachMe Physiology, 2021). The same study also showed that patients with higher BMI required more frequent invasive mechanical ventilation (IMV) due to reduced pulmonary reserves and alterations of the chest-wall anatomy, contributing to their need for ICU admission. Obesity is also said to hinder the effectiveness of protective immune functions.

Strengths of the systematic review and implications of the research

This systematic review adhered to a rigorous methodology, screening a large number of journal articles before critically determining those relevant to the research question. Studies from a large range of geographical locations were acquired, and the relationship found has been corroborated with several other studies, including previously conducted meta-analyses on obesity and COVID-19. Being a study that compares the association between these two variables for patients of different geographical backgrounds has crucial implications. This is considering that firstly, there are differences in BMI categories for each geographical group, and secondly, there are varying practices in place from country to country regarding patient care and disease management. Determining distinct associations between the

variables for different geographical backgrounds would therefore provide medical experts in relevant countries with a foundational knowledge for the need for special monitoring of COVID-19 patients with obesity.

Limitations of the research

A key limitation of this research is the limited range of Asian-centric studies included; given that only three were found to be relevant, this significantly impacted the accuracy and representative nature of the relationship found between obesity and adverse clinical outcomes. Secondly, the statistical analysis conducted was highly simplistic and primarily utilized a simple bivariate scatter plot, which may not serve as detailed, encompassing evidence for the relationship between the two variables. The research also did not consider the influence of other factors and their implications on the severity of clinical outcomes. Finally, when gathering data on the number of patients with varying BMI, the values extracted were limited to large groups, defined by "Obese" and "Non-Obese", which do not account for further sub-categories that may have had their own significant association with clinical outcome severity.

Potential Future Research

Whilst one of the criteria used to screen the chosen articles was that the age group was to be adults above the age of 18, most of these studies constituted patients the middle age, which calls into question the relationship between age, BMI and outcome severity. Few studies have discussed this, thereby serving as scope for further research. Additionally, conducting a multivariate statistical analysis would be quite beneficial. This would also allow for the consideration of other factors and their influences, such as more specific chronic diseases like diabetes, that are closely interrelated with obesity. Further investigation into the association between these variables across a more specific range of geographical locations would also be beneficial, as opposed to limiting the research to a distinction between Western and Asian countries. Given that vaccination programs are currently being implemented across various countries, it would be interesting to understand whether there is a relationship between these variables and the effectiveness of the COVID-19 vaccine.

Conclusion

In conclusion, the systematic review and basic statistical analysis conducted reinforced that there is a relationship between obesity and the incidence of adverse clinical outcomes. Given that the pandemic is still ongoing, physicians and healthcare professionals should utilize this, and other research, to more closely monitor and treat patients with higher BMI's earlier, thereby reducing the risk of complications.

Conflicts of interest

The author has no conflict of interest to declare.

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