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Research Paper

Risk Factor Dynamics: Obesity, Diabetes, And Post-Covid-19

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Abstract
As reported by the World Health Organization (2023), COVID-19 has resulted in approximately 6.9 million confirmed deaths globally, with an estimated case fatality ratio (CFR) of around 0.9%. Although COVID-19 was among the leading causes of mortality during the peak pandemic period, its ranking as a global cause of death varied across regions and time periods. In 2021, 10.5% of persons aged 20 to 79 globally had diabetes (IDF, 2021), and 1 in 8 adults were obese, according to the WHO and the Global Burden of Disease (WHO, 2023; GBD Collaborative Network, 2020). Diabetes and obesity, two diseases that are common throughout the world, greatly raise the risk of catching COVID-19 and can have long-term effects and cause multiple organ systems to malfunction. Analyzing the dynamics of risk factors linked to COVID-19 infections was the goal of this study. Body Mass Index (BMI) is a widely used anthropometric measure for assessing the relationship between an individual's weight and height, calculated as weight in kilograms divided by height in meters squared (IFSO-EC, n.d.). To determine whether a person had diabetes, random blood glucose tests were performed. 1857 willing participants were included in this study, and their blood glucose, BMI, and COVID-19 infectivity status were evaluated. Of these, 44% were overweight or obese, 10.9% had diabetes, and 24% tested positive for COVID-19.

Keywords: *BMI, Body Mass Index, Diabetes, Obesity, Post-COVID-19, logistic regression*

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I. Introduction

The COVID-19 pandemic has changed public health worldwide because of its immediate high morbidity and mortality rate. It has resulted in long-term effects on human health, which is commonly termed the "post-COVID-19" condition, or long COVID. This syndrome includes chronic symptoms such as breathlessness, fatigue, metabolic disturbances, and cognitive impairment that may persist for weeks or months after recovery (World Health Organization, 2025).

Pre-existing comorbidities, particularly obesity and diabetes, resulted in the severity of acute COVID-19 and the risk of developing long COVID (Khunti et al., 2021). Diabetes and obesity were widespread throughout the world before the pandemic. This was mainly due to unhealthy lifestyles, urbanization, and poor diets. The World Obesity Federation (WOF) and the International Diabetes Federation (IDF) say that by 2030, more than 1 billion people will be obese and 643 million adults will have diabetes (WOF, 2022; IDF, 2021). These conditions affect metabolism, reduce immunity, and cause inflammatory responses, so they result in increasing susceptibility to infections and other diseases like COVID-19. (World Health Organization, 2025; Centers for Disease Control and Prevention, 2020).

Research has shown that people with obesity or diabetes are more likely to be hospitalized or die from severe COVID-19 (Ayoubkhani et al., 2021). A compromised immune system, persistent inflammation, issues with blood vessel linings, and an increased presence of ACE2 receptors in adipose tissue facilitate viral entry (Karki et al., 2021). Moreover, COVID-19 has been associated with diabetes development that points to a two-way link between SARS-CoV-2 infection and metabolic imbalance (Rubino et al., 2020).The pathophysiological pattern observed in response to virus invasion, as seen in Fig. 1, predisposes to each of these risk factors.

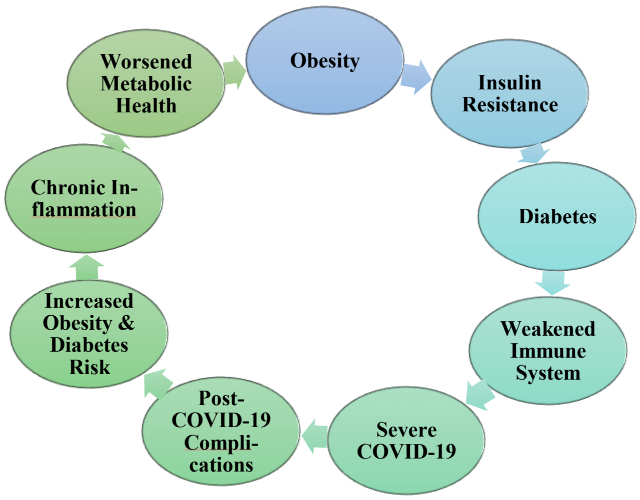

Fig. 1. Interconnected factors influencing self-reinforcing cycle(adapted from Apicella et al., 2020; Bornstein et al., 2020; Karki et al., 2021; Sattar et al., 2020).

People already suffering some kind of metabolic derangement are more likely to deteriorate after the virus. This issue is most likely due to chronic inflammation, injury to the blood vessels, and impaired absorption of glucose. The cohort research demonstrates how vital it is to begin with a healthy metabolism. Immunization status, age, gender, and behavioral disorder (e.g., hypertonia or addiction) were some of the factors that have been reported to have a significant influence on the long-term result of such acase. (Chen et al., 2022).

Although numerous studies have investigated singular risk factors, the dynamic interactions among obesity, diabetes, and post-COVID-19 complications within specific population groups remain underexplored. This research aims to fill that gap by analyzing population-level data and evaluating the effects of demographic and behavioral variables, encompassing age andsex.

II. Materials And Methods:

Study design

After approval from the institutional ethical committee, a retrospective cross-sectional cohort study was conducted from January 2024 to December 2024 (12 months) in various regions of South Gujarat (Creswell, 2017). Participants were recruited using a stratified sampling approach during health check-up campsto avoid bias from volunteer participants after their willing consent (Etikan et al., 2016). Free health check-up camps were organized in collaboration with various healthcare setups/companies (Shivam Chest Clinic, Kiran Hospital, Vrudam Hospital, Cipla, etc.). Individuals are willing to participate in a health checkup camp. Including both genders, ages above 18 years were included, and those individuals who were unwilling or unable to provide informed consent, were pregnant or breastfeeding, or were participants less than 18 years of age were excluded from this study. By following the inclusion and exclusion criteria, a total of 1857 individuals voluntarily participated and provided informed consent prior to the study. Theflow of study design and participant selection process is shown in the fig. 2.

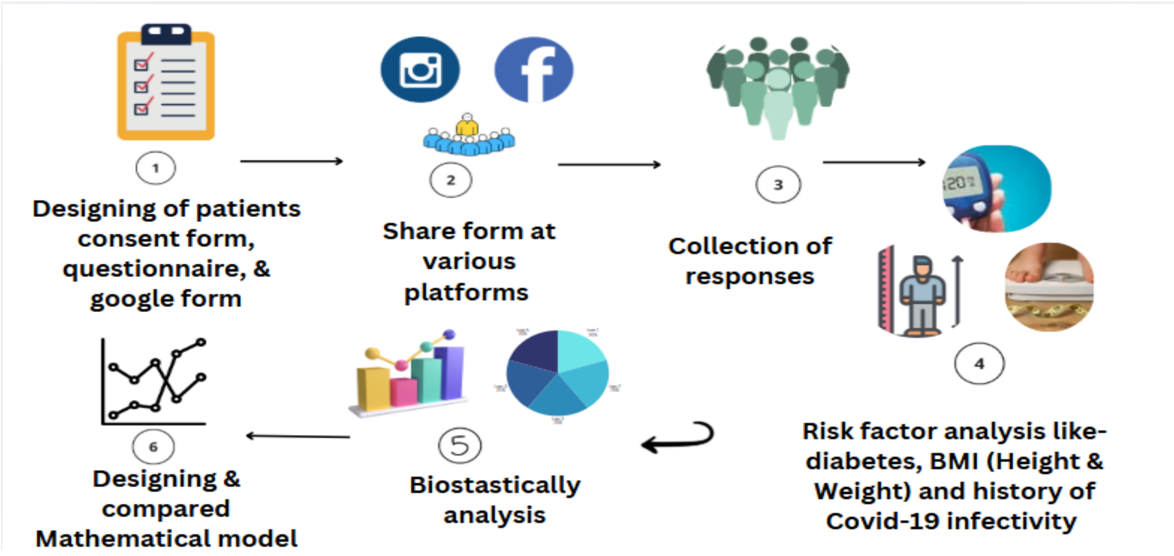

Fig. 2. Flow of study pattern.

III. Data collection

Demographic details, such as gender and age group, were recorded on standardized questionnaires. Participants were requested to provide their history regarding COVID-19 infection.

The clinical evaluation of all cases involved the assessment of Body Mass Index (BMI) and Random Blood Glucose (RBG) levels, which were determined during the complimentary health checkup camps. Participants' height and weight were measured in meters and kilograms, respectively, utilizing standard calibrated instruments.

Body Mass Index (BMI) was calculated using the formula BMI = weight (kg) / height (m^2) (IFSO-EC., n.d.). Following the World Health Organization's guidelines, all BMI results were classified into four distinct categories. Participants were classified as underweight, normal weight, overweight, and obese, defined by the World Health Organization (WHO, 2025).

The diabetes screening was performed using a portable glucometer for random blood glucose (RBG). An RBG $\geq$ 200 mg/dL was considered diabetes according to the American Diabetes Association criteria. Values under these cutoff points were considered non-diabetic. (ADA, 2023)

IV. Data analysis

All collected data were subsequently recorded and tabulated in Google Sheets and Excel documents. Statistical analysis was performed using JMP and Microsoft software. In this study,COVID-19 infection status was considered the dependent variable, while obesity status, diabetes status, age, and gender were independent variables.All continuous variables were used for calculating means with standard deviations, whereas frequencies with percentages were calculated for categorical variables. These descriptive statistics were used to assess the baseline characteristics of the participants.(Wallace et al., 2019)

Pearson's chi-square tests (bivariate analysis) were used to verify the association between dependent and independent variables. $p < 0.05$ was considered statistically significant.

For the analysis of the interaction between obesity, diabetes, and COVID-19 infection, logistic regression models (multivariate analysis) and decision tree models (CART algorithm—Classification and Regression Trees) were used.

Further, we used decision tree modeling to evaluate classification accuracy and interactions between predictors. Moreover, the two models compare and validate the statistical results. The model was designed to describe the dynamic interplay between the risk factors and the outcomes of COVID-19 and to make predictive insights.

V. Results

- **Descriptive analysis:**

A total of 1857 participants were included in the current study to evaluate the association between obesity, diabetes, and post-COVID-19 complications. All participants were categorized by gender and age group.

Gender distribution demonstrated that the majority of the participants were males, with 52.3%, compared to females, with 47.7% (more participants from industry). The most represented age group was the adults' group (49%), followed by the young adults (29%), and the mean age of the participants was 43±15 years. The mean of the body mass index (BMI) of the participants was 24.04±4.8 kg/m², with 12% of participants classified as obese and 32% in overweight categories.Random blood glucose tests revealed 10.9% with potential hyperglycemia, suggestive of diabetes. Table 1 presents the demographic and behavioral distribution based on COVID-19 infection status among participants with a p-value, and it reveals that the median sex distribution was the same for both infected and uninfected patients, regardless of gender.

Table 1. Participant's COVID-19 Infection Status (n = 1,857)

Variable	Category	Infected (n = 466)	Uninfected (n = 1391)	P-value
Gender	Female	28.54%	28.49%	0.9762
	Male	71.46%	71.51%	
Age group	Adult	51.00%	49.00%	<0.0001
	Child	1.29%	5.90%	
	Senior	25.50%	12.00%	
	Young adult	21.23%	32.25%	
Obesity	Normal	50.21%	59.45%	0.0023
	Overweight	35.62%	28.90%	
	Obese	14.95%	11.65%	
Diabetes	Diabetes	16.09%	8.12%	<0.0001
	No diabetes	83.91%	91.88%	

- **Analysis of Logistic Regression Model**

A logistic regression model was used in 1857 volunteer participants to assess the association between being infected with a disease and multiple prognostic factors (such as having diabetes and obesity). In this model, the incidence of diabetes was identified as the most common cause that influences the prevalence of COVID-19 infection compared to obesity.

People with diabetes were about 46% more likely to be infected with COVID-19 compared to those who did not have diabetes (odds ratio [OR] = 1.46, 95% CI: 1.24 to 1.705, $p < 0.0001$), and this association is statistically significant. Conversely, individuals who had a normal body mass index (BMI) experienced lower infection rates than the overweight, with a reduction of 21% in the odds of infection (OR = 0.79, 95% CI: 0.68 to 0.92, $p = 0.0020$). However, in this sample, obesity alone was not a significant factor for the increase in infection risk (OR = 1.12, $p = 0.3012$). Maybe obesity with other factors is responsible for increasing the chance of infections.

The result from the lack of fit test did not show that there were any serious problems with the model ($p = 0.4551$), indicating that our model was appropriately specified. Wald's chi-square test revealed that diabetes ($p < 0.0001$) and obesity status ($p = 0.0043$) were the strongest predictors of contagion.These results emphasize the role of diabetes and BMI and shed light on the progress of model refinement that can enhance the prediction of the model.

- **Decision Tree Analysis**

A model of a decision tree classification that was used to predict the infection status of 1,857 people by using diabetes and obesity status as predictors. The model created 5 different terminal nodes (leaves) based on combinations of these risk factors. The total number of splits in the tree is 5, where the first and most significant split is made based on diabetes status. This division of the data implies that the major role of diabetes was in the data and in the infection classification, which is represented in Fig. 3.

The decision tree analysis identified diabetes status as the most significant predictor of COVID-19 infection risk based on the greatest log worth value of 5.63 in the root node. The initial significant split between participants with and without diabetes (n = 188 vs. n = 1669) demonstrated that participants without diabetes had a wider distribution of stratification. Within non-diabetic participants, obesity status further stratified risk. Participants with a healthy BMI (n = 965) expressed the least risk, indicated by the greatest G^2 value (974.04), while those who were overweight or obese (n = 704) presented elevated risk (G^2 = 830.84). In this subgroup, those who were overweight (n = 503) made the largest contribution to infection risk (G^2 = 593.00) in comparison to obese individuals (n = 201, G^2 = 237.84).

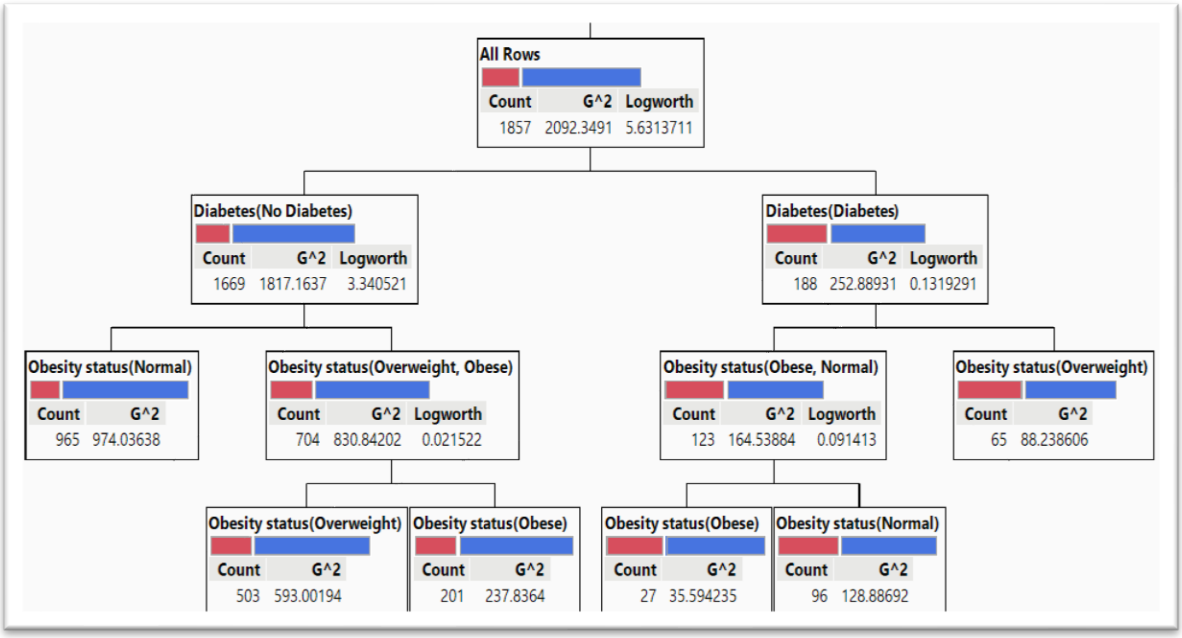

Fig. 3. Association of risk factors (decision tree model)

Conversely, in diabetic participants, the predictive ability of obesity status was less robust. Diabetic participants were divided into two major branches: one consisting of obese and normal BMI participants (n = 123), and the other consisting of the overweight subgroup (n = 65). In the first cluster, non-obese (n = 96, with normal BMI) subjects had greater G^2 (128.89) than the obese subgroup (n = 27, G^2 = 35.59), indicating unanticipated risk among non-obese diabetics, most likely attributable to other predisposing vulnerabilities. The group of overweight diabetics also expressed moderate predictive power (G^2 = 88.24). These results highlight that, although diabetes is the overriding predictor of infection, obesity status, specifically being overweight, has a major secondary role in determining infection risk in non-diabetic individuals.

The G^2 statistic was computed to evaluate each variable's contribution. Diabetes was responsible for 64.15% of the model's explanatory power (G^2 = 22.3). Obesity status was the cause of the loss of 35.85% (G^2 = 12.5), which is shown in table 3. Therefore, we can observe that the most significant metabolic risk factor (diabetes) plays a crucial role in COVID-19 infection.

- **Logistic regression model vs. decision tree model**

Both of the mentioned models (the logistic regression model and the decision tree) provided some guidance on how the course of diabetes and obesity influences the infection status. The logistic regression model pointed out a major breakthrough in the field: that there is a statistically significant infection odds ratio among people suffering from diabetes (OR = 2.13, $p < 0.0001$) and that normal weight was a protective factor in the face of overweight (OR = 0.79, $p = 0.0020$). In other words, the diseased condition (if any, i.e., obesity) did not predict the risk group with statistical significance ($p = 0.3012$). These results were in the same line as the decision tree ones, which echoed that diabetes and obesity were the major drivers of observed infection risk. Specifically, those who were overweight and had diabetes had the highest risk of infection (41.3%).

Although the tree was very easy to understand. The logistic regression method was statistically more substantial in examining the relationship between the factors, whereas the decision tree was better suited for grouping the population based on their level of risk. Hence, the joint use of both methods in further research work would lead to the creation of a more comprehensive risk profiling framework.

VI. Discussion

The study's findings reveal a significant influence of age and gender on the risk of COVID-19 infection. In particular, the age group exhibited the strongest relationship with the incidence of the infection ($p < 0.0001$). The senior participants who were infected (25.5%) made up a disproportionately higher part of the cases compared to the uninfected group (12.0%), while the young adults were mainly found among uninfected individuals. This result is consistent with global findingsthat say older people are more likely to develop COVID-19 because their immune systems are weaker and they have more health problems (Mueller et al., 2020).

Table 1 shows that the median sex distribution of infected and uninfected participants was the same across groups, with a consistently higher number of males (~71%). However, the difference observed was not statistically significant ($p = 0.9762$) within each social group. This finding parallels patterns described at the global level, where males were found to be more likely to develop COVID-19 infections because of owing partly to biological (e.g., hormonal factors and immune response) and partly to behavioral (e.g., smoking habits and occupational exposure) differences (Peckham et al., 2020; Jin et al., 2020).

Furthermore, both obesity and diabetes were highly correlated with infection status ($p=0.0023$ and $p<0.0001$, respectively). Individuals with overweight or obese BMIs as well as diabetes had increased infection risk, which exemplifies the role of metabolic conditions as major risk factors for both infection and increased severity of COVID-19 (Sattar et al., 2020). These data highlight the importance of targeted prevention, considering biomedical, demographic, and behavioral factors in the management of post-COVID health risks.

The logistic regression model revealed that the likelihood of infection in individuals diagnosed with diabetes was more than two times higher (OR = 2.13, $p < 0.0001$). The chi-square test statistic value was 58.28. The corresponding p-value was less than 0.0001. The previous research on the immunological deficiency and the proinflammatory status of the diabetic patients are key processes of the susceptibility of this group to infectious diseases (Bornstein et al., 2020; Apicella et al., 2020).

On the other hand, when comparing normal BMI and overweight, normal BMI had a protective effect, with 21% lower odds of infection (OR = 0.79, $p = 0.0020$). However, obese individuals (compared with those with normal BMI) were not found to be significantly predictive of this outcome (OR = 1.12, $p = 0.3012$), suggesting that obesity alone is less likely to be a major cause of infection. (Ayoubkhani et al., 2021).

VII. Conclusion

According to the study's findings, people who have diabetes were much more likely to be infected with COVID-19. A normal BMI did seem to be protective. However, obesity alone was not a risk factor. The highest risk of infection, according to the decision tree, was determined by diabetes and being overweight. Logistic regression and decision tree models, despite their limited predictive accuracy (AUC ~0.578), provided complementary advantages, including risk stratification and statistical inference capabilities.

Furthermore, factors such as middle age, male gender, a history of addiction, and undiagnosed diabetes could also contribute to the risk of infection. By including these factors in future models, infection risk prediction could be enhanced and focused public health initiatives could be supported.

VIII. Future Directions

This study identifies diabetes as the key predictor of an elevated level of risk for COVID-19 infection. BMI is also important for metabolic health and susceptibility to infection. The addition of other clinical and behavioral markers, such as immune markers, previous exposure to COVID-19, level of physical activity, and time of vaccination, will improve predictions in the future. Some complex predictive modeling techniques, such as random forests and gradient boosting, might perform well. Thus, a combination, logistic regression, is used to model inferences, and tree-based methods are used for classifications that may provide a more informative picture of the risk of infection in a public health context.

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Author contributions

Komal Zinzala conceived of the study and manuscript writing.

Dr. Manisha Shah oversaw the study, gave intellectual inputs, and approved the final version of the manuscript. The final draft was read and approved by both authors.

Conflict of interest

There are no conflicts of interest.

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