Effects of obesity in outpatient mental health treatment
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Executive Summary

In the US, 40% of the adult population is obese, becoming a health burden. Obesity is related to different diseases and poor mental health. However, there are inconsistencies about the relationship between Obesity and poor mental health. The objective of this project to determine the association between obesity and outpatient mental health treatment and which covariates might influence it, using the NSDUH dataset. A weighted logistic model adjusted with a loess and glm regression line was done to determine the relationship between obesity and outpatient mental health treatment without covariates. Then, different additive models and model with interaction were done to determine which of those covariates influence the association. Finally, a weighted logistic model considering those covariates and the odds ratio was calculated. As a result, BMI and outpatient mental health treatment relationships without covariates indicate obesity paradox. Covariates as alcohol consumption, education level, and income strata seem to influence the association. The weighted logistic model adjusted with the covariates shows that as BMI increases the risk of outpatient mental health treatment also increases. However, the odds ratios indicate no association between BMI and the risk of outpatient mental health treatment. More research and exploratory data analysis are required.

Introduction

The concerns of health issues related to obesity have been increasing in the past years to the increment of incidences in obesity among adults in the United States. The National Center for Health Statistics estimates that, for 2015-2016 in the U.S., 40% of adults aged 20 and over were obese (including 7.6% with severe obesity) and that another 31.8% were overweight. In 2013, the Organization for Economic Co-operation and Development (OECD) estimated that 75%of the US adult population would likely be overweight or obese by 2020. Obesity promotes a higher risk of numerous diseases like some types of cancer, coronary artery disease, type 2 diabetes, stroke, as well as significant increases in early mortality incidences and economic costs. That is why obesity has more awareness among the people and regarded as a major health issue. As well as obesity, mental health issues are an ongoing topic in the U.S. Particularly outpatient mental health treatment is a treatment involving periodic visits to a psychiatrist for a consultation, or at a community-based outpatient clinic. Regarding the severity and condition of a patient, the number of times the patient reaches the psychiatrist varies broadly. However, this is different from inpatients, who treatment where psychiatric patients while hospitalized. The recent trend of handling mental issues is more likely to treat as outpatients. Regarding the two important health issues obesity and outpatient mental health treatment, there have been ongoing debates about their association. There has not been conclusive evidence on whether obesity is associated with outpatient mental health treatment.

Statement of goal

O*ur main objective* is to explore the data about the 2018 National Survey on Drug Use and Health (NSDUH) and then fit a "complicated" logistic regression model to understand whether obesity has an association with having outpatient mental health treatment. We are trying to answer the following questions: (1) is there an association between obesity and having outpatient mental health treatment? If so, (2) which other factors might influence this association?

Methods

The methods section is organized into three sections: Section 2.1 the dataset and study sample; Section 2.2. presents the measurement for each variable including the outcome, exposure, and covariates; and Section 2.3 explains the analytical/statistical methods and generation of graphics.

2.1. Data and study sample

This study uses the 2018 National Survey on Drug Use and Health (NSDUH). The NSDUH, a nationally representative survey, is an annual cross-sectional survey of the civilian, noninstitutionalized population (age ≥ 12) in the 50 U.S. states and the District of Columbia about the consumption of illicit drugs and alcohol in the US. Details information about the NSDUH has been published elsewhere (Center for Behavioral Health Statistics and Quality, 2019). Of the 56,313 participants of 2018 NDSUH, those younger than 18 years (N = 13,287) were excluded from the analytical sample given that some mental health items were not measured for this population. We also excluded missing data on mental health items and BMI (N = 2,105), leaving a final analytical sample of 40,921 U.S. adults aged 18 or above.

2.2. Measures

The exposure, body mass index (BMI) is a measure of body size. It is calculated through the combination of an individual's weight in kilograms compared by the square power of its height in meters. It is the standard measurement to approximate obesity in an individual. It is a common practice in the health sciences to categorize the BMI based on the standard cut-offs defined by the World Health Organization (WHO). Those who are underweight have a BMI lower than 18.5 (<18.5), normal weight individuals are between 18.5 and 24.9 (18.5≤ BMI <24.9), overweight individuals are between 25.0 and 29.9 (25.0 ≤ BMI < 29.9) and obese individuals have a BMI greater than 30.0 (BMI> 30.0).

A binary measure of outpatient mental health service utilization in the past year was used as an outcome variable (1 = Yes, 0 = No). For independent variables, we used five different variables: (1) body mass index (continuous variable), (2) past-month use of alcoholic beverage (1 = Yes, 0 = No), (3) past-year thought about killing self (1 = Yes, 0 = No), (4) educational attainment (1= less than high school, 2 = high school or graduate, 3 = some college or associate degree, 4 = college graduate), and (5) total family income (1 = less than $20,000, 2 = $20,000 - $49,999, 3 = $50,000 - $74,999, 4 = $75,000 or more).

2.3. Statistical analyses and graph generation

The statistical analysis had the following strategy. First, for exploratory data analysis, we illustrated each variable by displaying frequencies and distribution (for the BMI); to visualize differences between categories (e.g., yes vs no for past-year suicidal thought) for each item histograms, bar plots, and boxplots were used. Second, to determine the association between BMI and past-year outpatient mental health service utilization we used a weighted bivariate logistic regression model. Furthermore, a non-parametric loess regression was used to compare the results of logistic and loess regression by plotting both regression lines. Third, to examine interaction effects between BMI and other covariates on the mental health outcome, four different trivariate logistic models were conducted; each consists of an additive model (i.e., without interaction) and an interaction model. Four, to examine simultaneously all covariates and visualize their effect in the association, a full model was fitted without interactions.

The odds ratios (OR) and corresponding 95% confidence intervals (CIs) were used to present all of the associations. The ORs provides information on the association of the outcome with exposure/covariates, adjusting for all other independent variables in the multivariate logistic models. The corresponding CIs provide information on statistical significance and practical significance of the difference identifying the uncertainty of the estimate and magnitude of a difference estimate (Rothman, Greenland, & Lash, 2008). All statistical analyses and graph generation were performed using R version 3.6.1 (R Core Team, 2019). Specifically, we utilized the ggplot package to generate the graphs and the general linear model (glm) and loess function for the statistical modeling. Syntax to reproduce the analyses is uploaded as a separate file.

Results

The results section is organized in the following sections. First, the descriptive statistics of the exposure, outcomes, and covariates of interest. Second, graphs that explain the associations between BMI and all-cause mortality. Third, the considered covariates that might influence this association. Finally, the odds ratios obtained in our logistic model.

3.1 Descriptive statistics

This section describes BMI, the exposure, the outpatient mental health treatment, our outcome, and covariates based on our outcome.

Figure 1 - Histogram of Body Mass Index (BMI)

Figure 1 shows the histogram of the BMI. For the BMI, the mean is 28, the median is 26.8 and the standard deviation is 6.4. Therefore, the average participant in this study is in the overweight category. From the mean to standard deviation, we can see that more than 64% of participants are overweight or obese. The range of the distribution varies from 9.3 to 68.55. The outliers were not removed because it is biologically possible a BMI lower than 15 or greater than 45.

Histogram of BMI

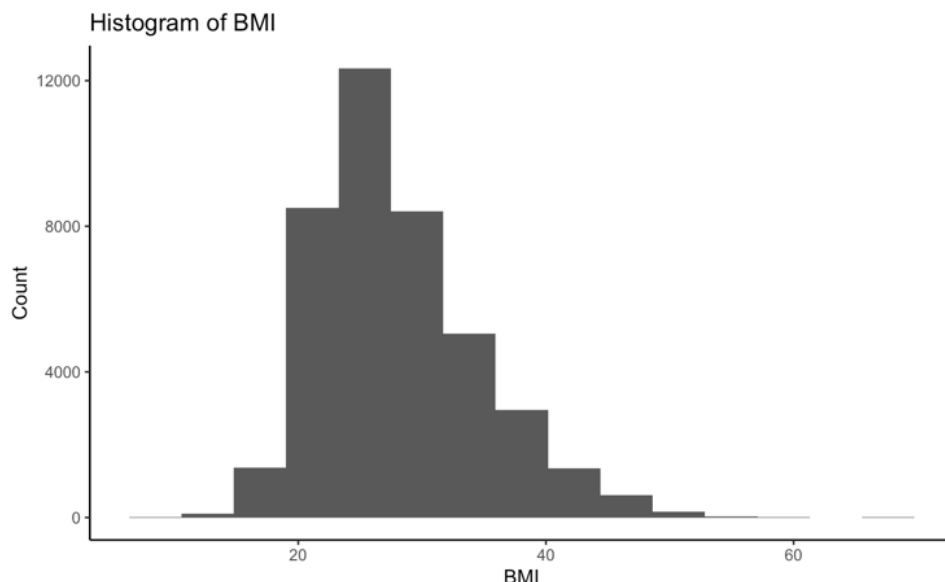Boxplot of BMI Regarding Having Out Patient Mental Health Treatment
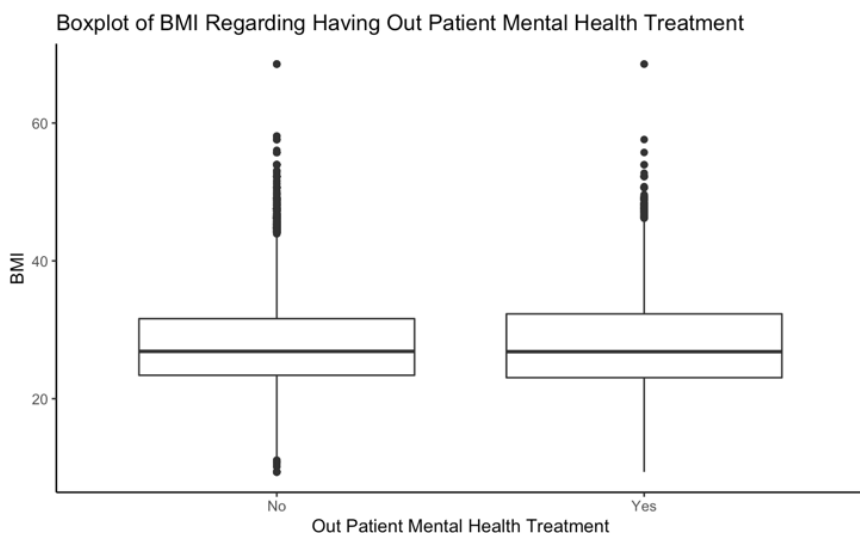
Figure 2 - BMI respect outpatient mental health treatment use

Figure 2 shows the BMI respect being an outpatient mental health treatment. The group which had not received treatment has a mean of 28 and a standard deviation of 6.3 while the group which had received treatment has a mean of 28.3 and a standard deviation of 7.1. The median for both groups was 26.8.

Figure 3 - Bar plot of outpatient mental health treatment

Figure 3 shows that most of the participants do not receive outpatient mental health treatment. Considering that our sample size is 40,921, around 92% of participants (37,281 individuals) were not receiving outpatient mental health treatment while 3640 participants (8%) were receiving outpatient mental health treatment.

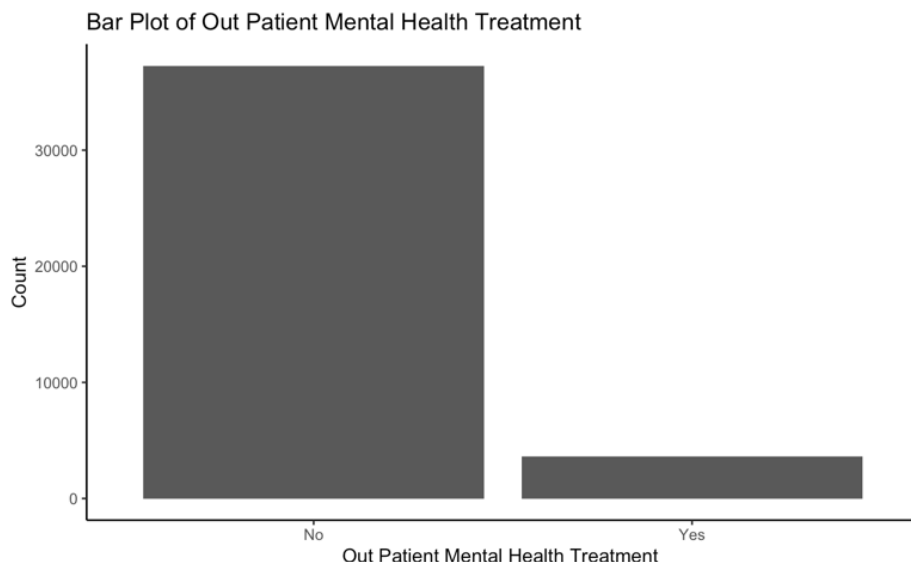Bar Plot of Out Patient Mental Health Treatment

Figure 4 - Bar plot of BMI respect outpatient mental health treatment

Figure 4 shows the categories of BMI respect to outpatient mental health treatment. Most of the participants did not receive outpatient mental health treatment. The underweight category has fewer participants receiving outpatient mental health treatment compared to all the other categories.
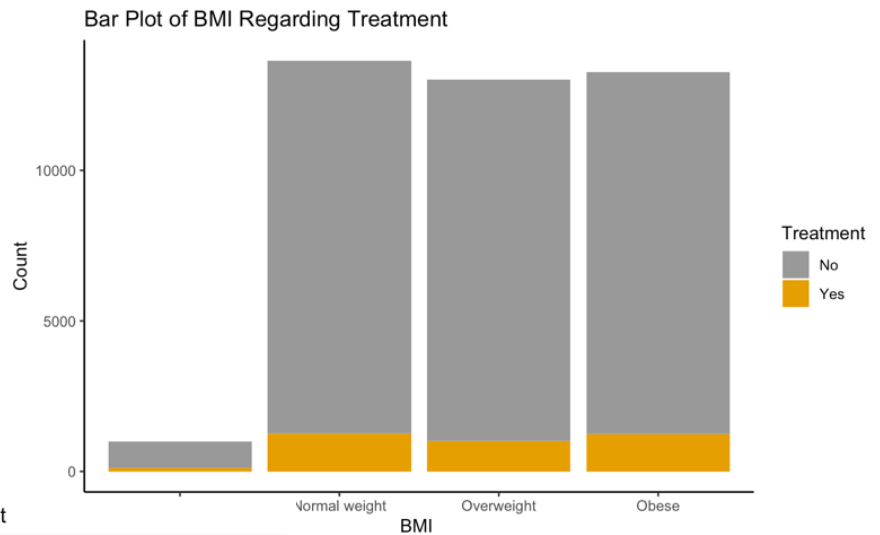

Bar Plot of BMI Regarding Treatment

Figure 5 - Bar plot of Alcohol regarding outpatient mental treatment

Figure 5 shows that most of the participants do not have outpatient mental health treatment regardless the alcohol consumption. Based on the plot most participants consume alcohol. In lieu, 57% of participants (23,532 individuals) consume alcohol. For those of 23,532 individuals (57%) who said yes to alcohol usage, 9% were receiving treatment.

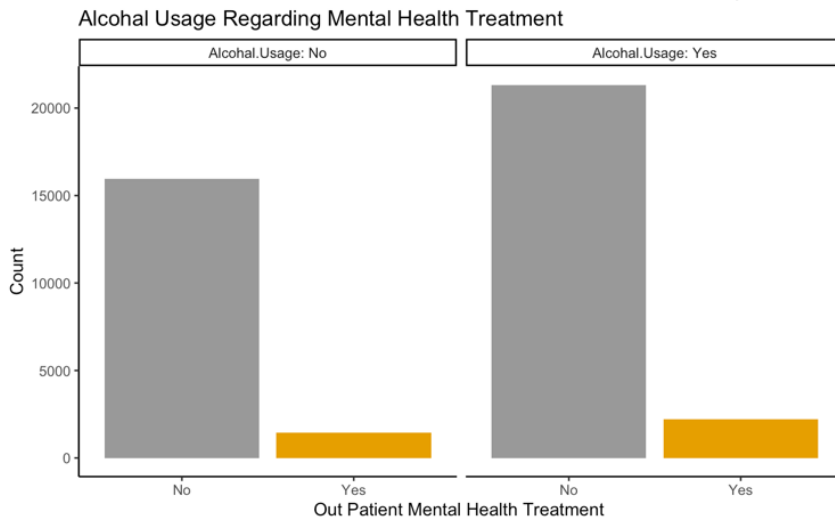Alcohal Usage Regarding Mental Health Treatment

Figure 6 - Bar plot of Suicide though regarding outpatient mental treatment

Figure 6 shows that most of the participants did not have thoughts of suicide. Regardless of suicide thoughts, most participants do not have outpatient mental health treatment. However, participants not having suicide thoughts use more outpatient mental health treatment compared to those with thoughts of suicide.
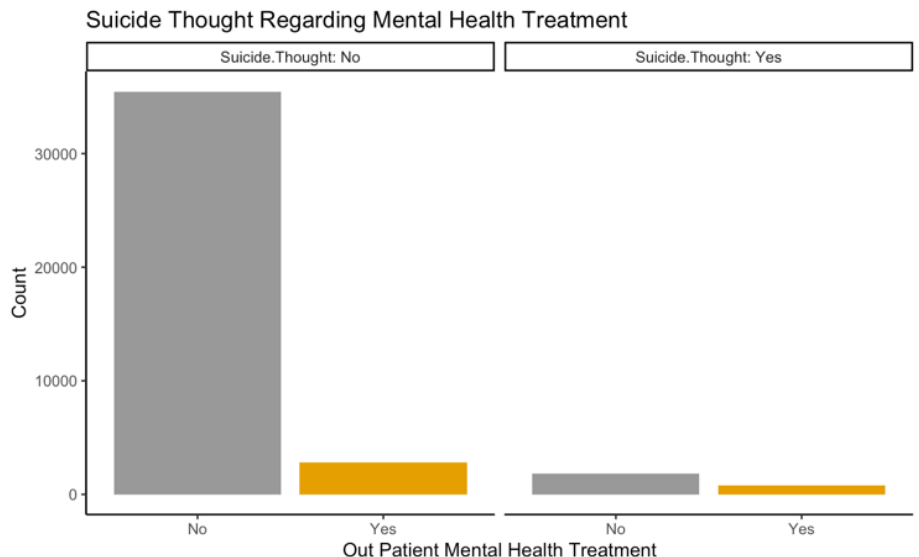

Suicide Thought Regarding Mental Health Treatment

Figure 7 shows that most of the participants have some college degree or are college graduates. Those with some college and college graduates have a higher frequency of outpatient mental health treatment compare to those with less than high school or just a high school diploma.
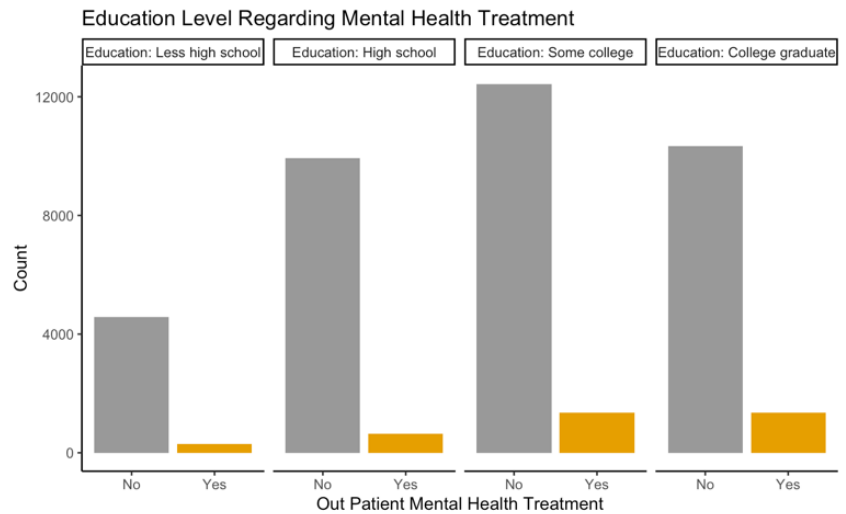

Education Level Regarding Mental Health Treatment

Income Level Regarding Mental Health Treatment

Figure 8 - Income regarding mental health treatment

Figure 8 shows that most of the participants in all income strata do not have outpatient mental health treatment. The frequency of those who receive outpatient mental health treatment is relatively similar. However, those with an income of $50,000- $74,999 have a lower frequency in participants that use outpatient mental health treatment. Finally, most of the participants have an income of around $20,000-$49,999 and $75,000 or more.
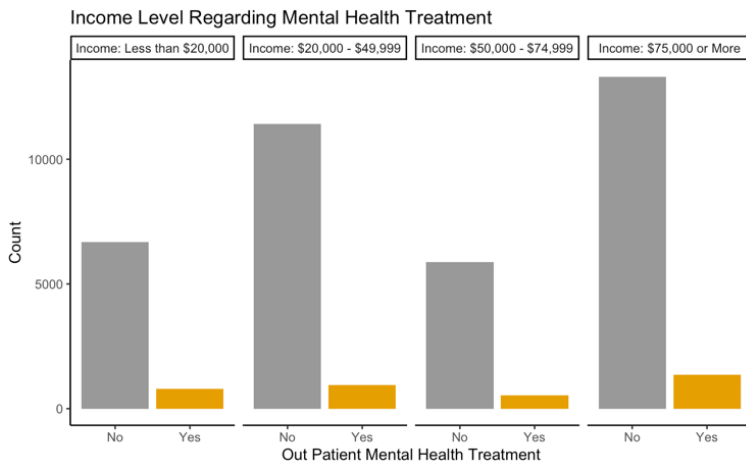
3.2 Initial model (only BMI and risk of outpatient mental health treatment)

This section shows our initial models when considering BMI and risk of outpatient mental health treatment only adjusted with a LOESS and GLM regression.
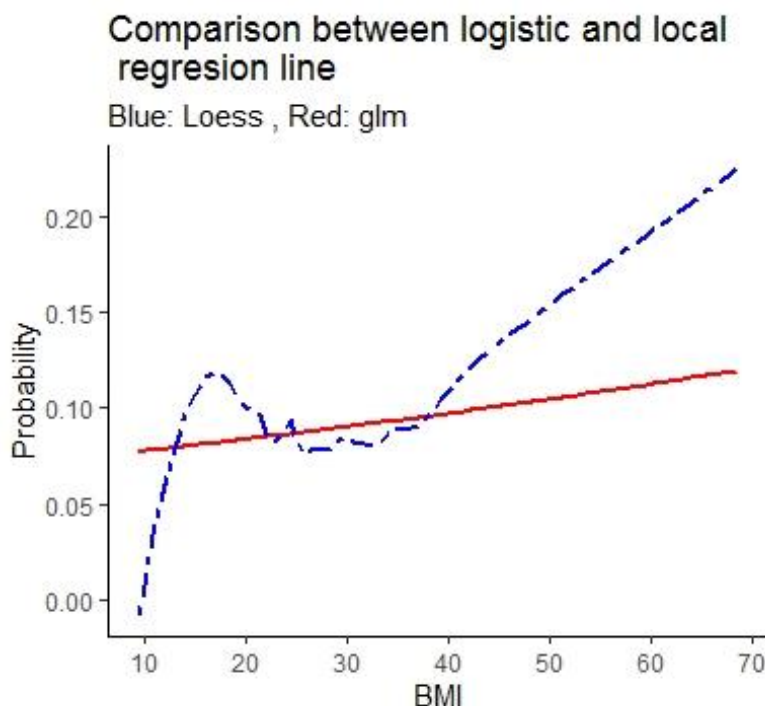

Comparison between logistic and local regresion line

Blue: Loess , Red: glm

Figure 9 - Comparison between logistic and local regression line

Figure 9 shows the relationship between BMI and the probability of outpatient mental health treatment (without covariates). The LOESS and GLM regressions were used to model the relationship. The LOESS regression (blue color) indicates that as BMI increases, the probability of outpatient mental health treatment also increases. However, when BMI is closer to 20, the risk starts to decrease. It increases again though it drops once again. However, it remains relatively plateau in a BMI between 20 and 30 until it started to reach 30. Finally, once again, it starts the trend that higher the BMI higher the risk of outpatient mental health treatment.

The GLM regression (red color) shows a linear trend that higher the BMI higher the risk of being outpatient mental health treatment.

3.3 Model comparison between additive and interaction models among covariates

This section compares an additive model (model without interaction) and a model with interaction among covariates to determine if an interaction between the exposure, BMI and that particular covariate is needed to determine the association between BMI and the outpatient mental health treatment.

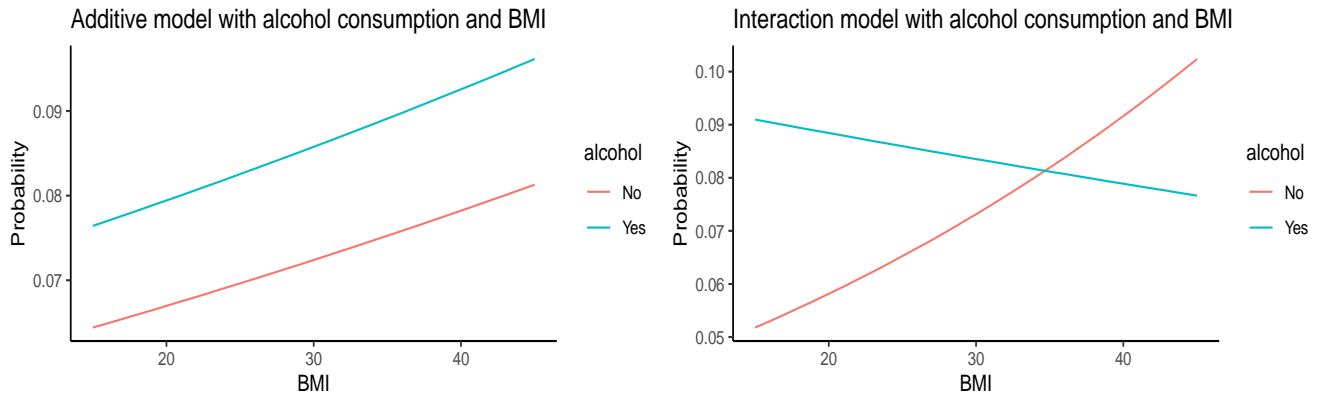**Figure 10. Model comparison between additive model and model with interaction.**

Figure 10a - Additive and Interaction model with alcohol consumption and BMI

Figure 10a shows the additive model between **BMI and alcohol consumption**. It seems those who consume alcohol are always at higher risk of being outpatient mental health compare to those who do not consume alcohol, regardless of the BMI. At the same time, it shows the probability of being an outpatient mental health increases as when adjusted for alcohol consumption. However, the model with interaction between alcohol consumption and BMI shows other behavior. Those who do not consume alcohol have a higher risk of being a mental health outpatient as the BMI increases while those who consume alcohol have a lower risk of being a mental health outpatient as the BMI increases. The alcohol and non-alcohol consumers group have interaction in a BMI greater than 30, indicating that obesity and alcohol consumption have an interaction.
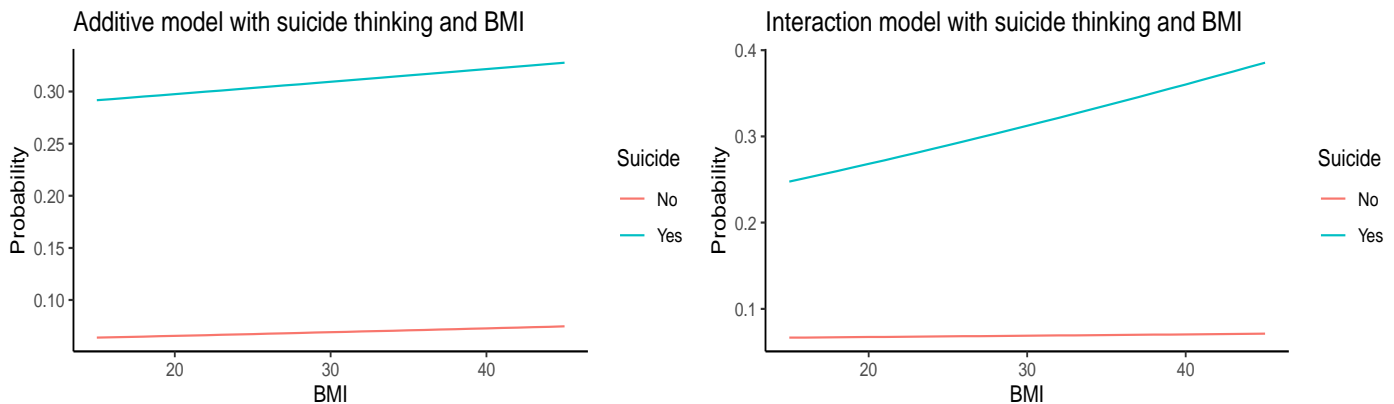

Figure 10b - Additive and interaction model with suicide thinking

Figure 10b shows that after fitting the additive logistic model with variables of BMI and people with and without suicide thinking, those with suicidal thinking are always at higher risk of being a mental health outpatient. In those with and without suicide thoughts, the risk increases as BMI increases. However, those who have suicide thinking have a higher increment compare to those without suicide thinking. A similar scenario is shown for the interaction model. Nonetheless, the interaction model shows a higher increasing rate of probability of being poor mental health for people with suicide thinking.
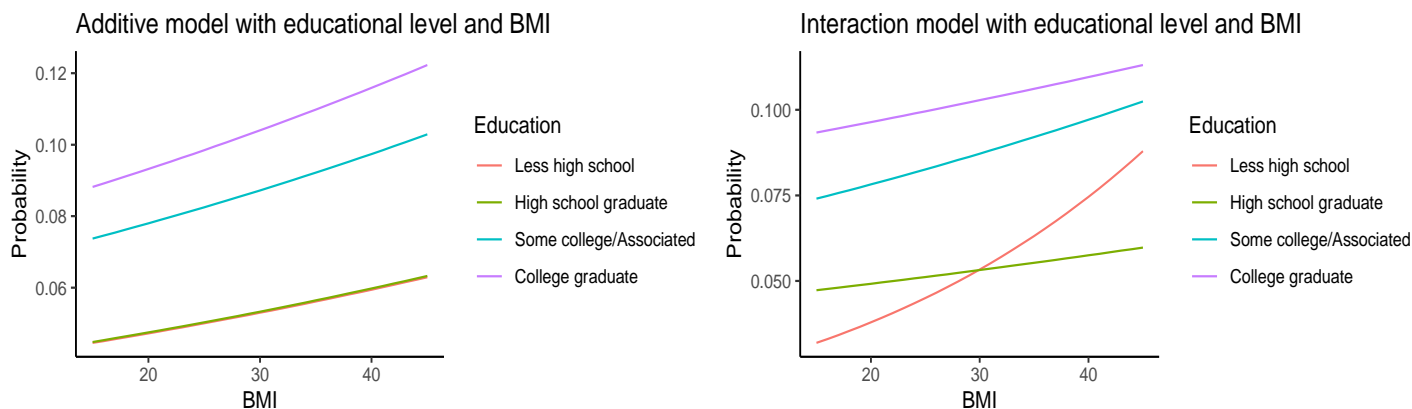
Figure 10c - Additive and interaction model with educational level and BMI

Figure 10c shows the additive and interaction model respect to **the BMI, probability of being a mental health outpatient and educational level**. In the additive model, the probability of being outpatient in a mental health facility for each group of the educational levels is increasing as BMI increases. College graduates are at the highest risk. Interestingly, those who have less than high school and those who graduate from high school has a similar probability. On the other hand, in the model with interaction, these two groups have a similar increasing rate as the model without interaction. However, those with less than high school in the lowest BMI values (i.e., underweight category), have the lowest probability of being a mental health outpatient compare to the other education levels. However, it starts to increase as BMI increases. In lieu, it has the fastest trend of increment among all education levels. Because those who have less than high school and have a high school diploma interacted, it seems there is an interaction between education level (mainly those two levels) and BMI.
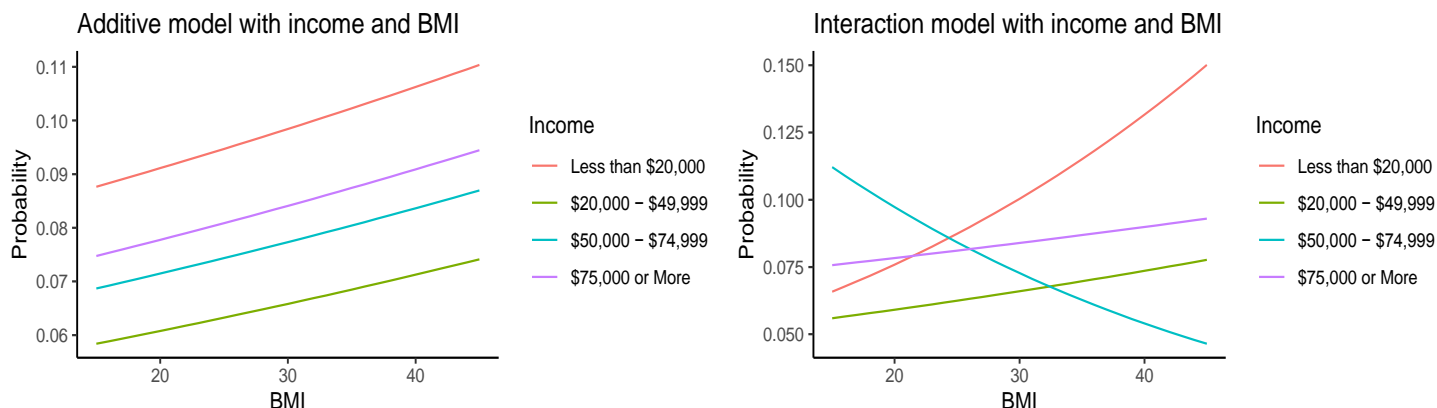

Figure 10d - Additive and interaction model with income and BMI

As to annual income for each group of BMI, Figure 5d shows in the additive model that those who have less than $20,000 for income are at the highest risk of using mental health facility whereas those who have an annual income between $20,000 and $49,999 are at the lowest risk. The interactive model shows that those with an income between $20,000 and $49,999 and more than $70,000 remain in a similar increasing rate; those with income less than $20,000 reflect the higher increasing rate of risk compared to the additive model. The participants who have income within the range of $50,000 to $79,999 show an unexpected decreasing risk of being poor mental health, having an interaction with all the other categories. Therefore, BMI and income have interaction. A possible explanation of this behavior in the income model can be seen in the Appendix section.

3.4 – Final model with BMI and predicted risk of outpatient mental health treatment and odds ratios
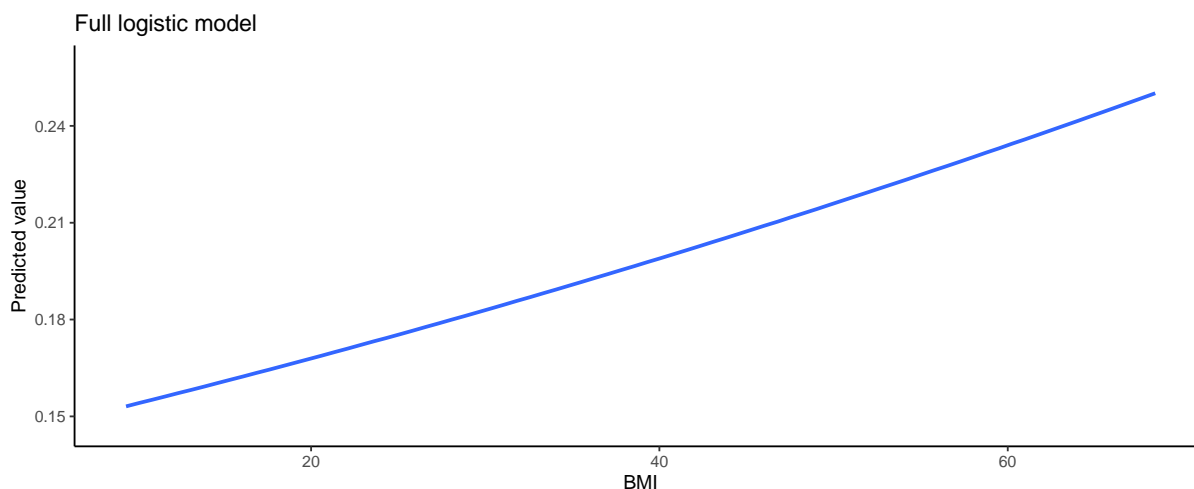
Full logistic model

Figure 11 - Final logistic model with BMI and predicted risk

Figure 11 shows the weighted logistic model with BMI and the predicted risk of outpatient mental health treatment considering all the covariates (without interaction). The plot shows a linear relationship that higher the BMI, higher the risk of the outpatient mental health treatment when considering income, education, alcohol consumption, and suicide thoughts. The association between BMI and outpatient mental health treatment was measured through the odds ratios (See Figure 12).
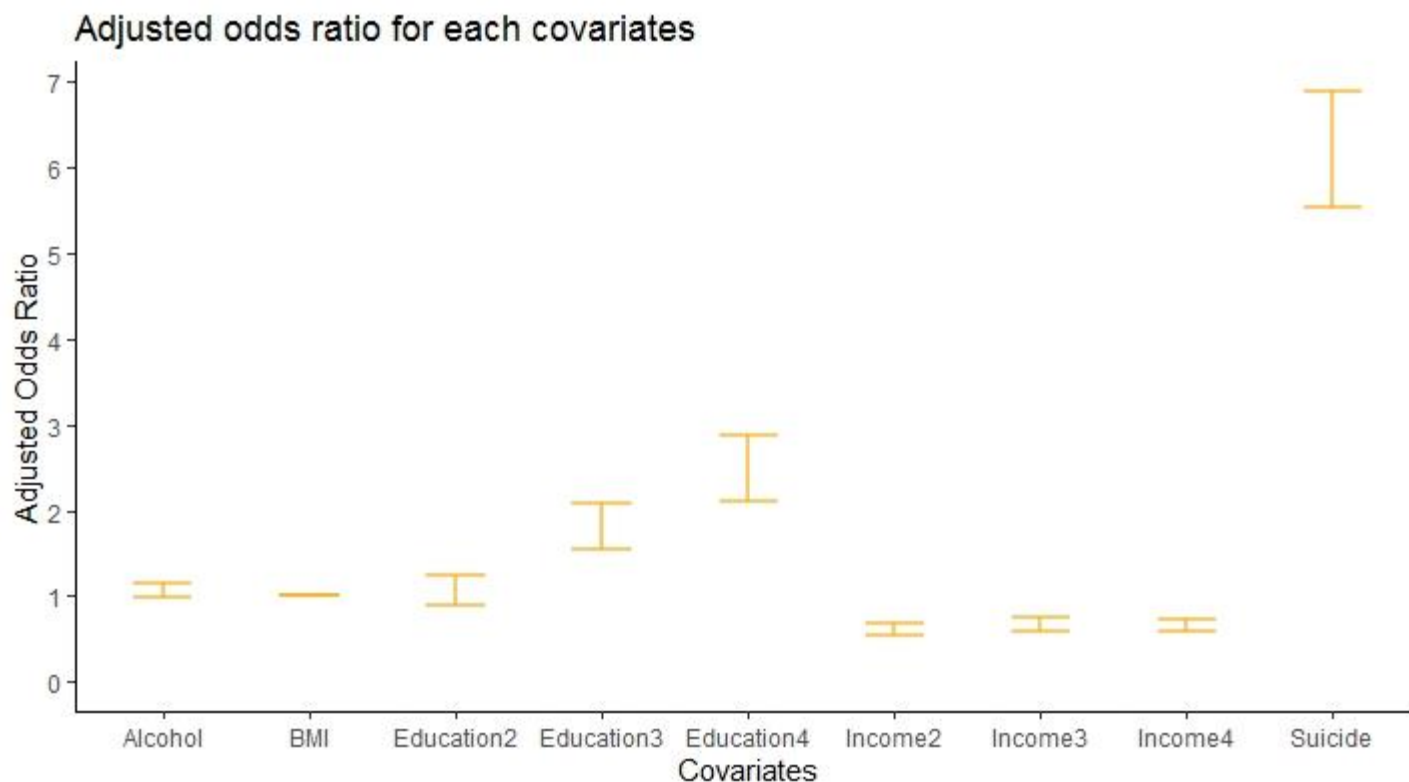

Figure 12 - Adjusted odds ratio for all covariates and exposures

When considering all covariate variables in the full model, we calculate the odds ratio and 95% and generate a plot to compare the difference between each covariate. All covariates are considered as categorical variables and BMI as a continuous variable. Subjects are non-alcohol consumers, with less than high school graduates, income that lower than $20,000, without suicide thinking, are all considered as the reference group. Based on Figure 12, the BMI odds ratio is close to 1.01. In other words, it seems there is no association between BMI and

outpatient mental health treatment. We suggest that the risk of being poor mental health and utilization of mental health facilities have no different among each level of alcohol consumption, educational level of high school graduates (compared with the group of less than high school), and income. However, the risk of being outpatient mental health for participants with some college education (or college graduates) is 2 times (2.3 times) as large as the odds for participants with less than high school education being poor mental health compared to those who are not outpatient mental health. Furthermore, the risk of being poor mental health for participants with suicide thinking is almost 6 times as large as the risk for participants without such thinking.

Discussion

Is there an association between obesity and having outpatient mental health treatment?

There is an association where higher BMI higher the risk of outpatient mental health treatment (Figure 9). However, when the BMI is close to 20, the risk started to decrease as BMI increases. Another change happened when BMI was close to 25, where it remains relatively the same. Nonetheless, when the BMI started to get close to 30, the risk started to increase again as BMI increases. This behavior indicates the obesity paradox. Those with a BMI lower than 18.5 (underweight) or greater than 30 (obese) have a higher risk of different health burdens compare to those who are normal weight or overweight.

However, when considering different covariates that might have an association with both obesity and outpatient mental health treatment, the behavior changes. Figure 11 shows that as BMI increases, the risk of outpatient mental health treatment also increases when considering the income strata, alcohol consumption status in the last month, education level, and suicide thinking of participants. Nonetheless, when considering the odds ratios, the interpretation changes.

Figure 12 shows the odds ratios of the exposure, BMI and other covariates. The odds ratios of the BMI respect to the risk of outpatient mental health treatment is close 1.00, interpreted as no association between BMI and the risk of outpatient mental health treatment when adjusted to income, education level, alcohol consumption in the past month, and suicide thinking status.

Which other factors might influence this association?

Five covariates were considered to determine if they influence the association between obesity and outpatient mental health treatment. The additive models and models with interaction in Figure 10 show that education level, income strata, and alcohol consumption status in the last month seem to have interaction with BMI. Therefore, obesity is related to these covariates and need to consider them when trying to determine the relationship between obesity and outpatient mental health treatment.

Figure 12 shows that those covariates are also related to the risk of outpatient mental health treatment. Interestingly, education level categories indicate that higher education levels, times higher the risk of outpatient mental health treatment, indicating a strong association between them. The same behavior occurs in suicide thinking. As expected, those who have suicide thinking have 6 times higher the risk compare to those without suicide thinking of outpatient mental health treatment.

However, income and alcohol consumption have other relationship direction. Income has an odds ratio lower than 1.00, which might indicate a protective association (if compare with those in the lowest income strata). This means that the higher the income, the lower the risk of outpatient mental health treatment compared to those with the lowest income strata. Nevertheless, alcohol consumption is relatively non-associated with the risk of outpatient mental health treatment.

Conclusions

The exposure, BMI, the outcome, outpatient mental health treatment, and the covariates were described to understand the data. An initial weighted logistic model was constructed only considering BMI and the outpatient mental health treatment status adjusted with a LOESS and a GLM regression. The LOESS regression indicates a very particular behavior where the extreme values of the spectrum of the BMI have a higher risk of outpatient

mental treatment that those who are within the center of the spectrum. Such behavior is known as *the obesity paradox*. Different covariates were included to adjust this association and see if there are any changes. The covariates were selected based on their interaction with the BMI, alcohol consumption in the last month, education level, and income strata. Another weighted logistic model was done considering those covariates and the relationship changed to linear, where higher the BMI higher the risk of outpatient mental health treatment. However, when considering the odds ratios, it seems there is no association between BMI and outpatient health treatment. More research is required to understand such inconsistency in the results and why that inconsistency occurs relatively often in the literature.

Limitations

The covariates and the outcome are self-reported, increasing the risk of information bias. Some of the variables as alcohol consumption do not have information on the frequency of drinking during that period when dichotomize. Normally, alcohol consumption is measured in the number of drinks per period. Other covariates as cholesterol, triglycerides, and other biomarkers were not considered in the study. Due to the uncertainty, outliers were removed because biologically they can be possible, though very unlikely.

Future work

It is considered that the inconsistencies of the results might be to how the outcome was operationalized. Perhaps considering the frequency of using those outpatient mental health treatment can provide more detail information that might explain why we are having the inconsistencies obtained respect to the interpretation of this association. Future analysis with other variables that measure the same variables as this study will be used and then compare to see if the operationalization of the variables plays a role.

Reference

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Roth Rothman, K. J., Greenland, S., & Lash, T. L. (2008). *Modern epidemiology* (Vol. 3). Philadelphia: Wolters Kluwer Health/Lippincott Williams & Wilkins. man KJ. Modern Epidemiology. Boston: Little, Brown & Co.; 1986

Appendix

Figure A1: Exploration for unusual pattern among participants with income from $50,000 to $74,999

Exploration for unususal pattern
Among participants with income from $50,000 − $74,999
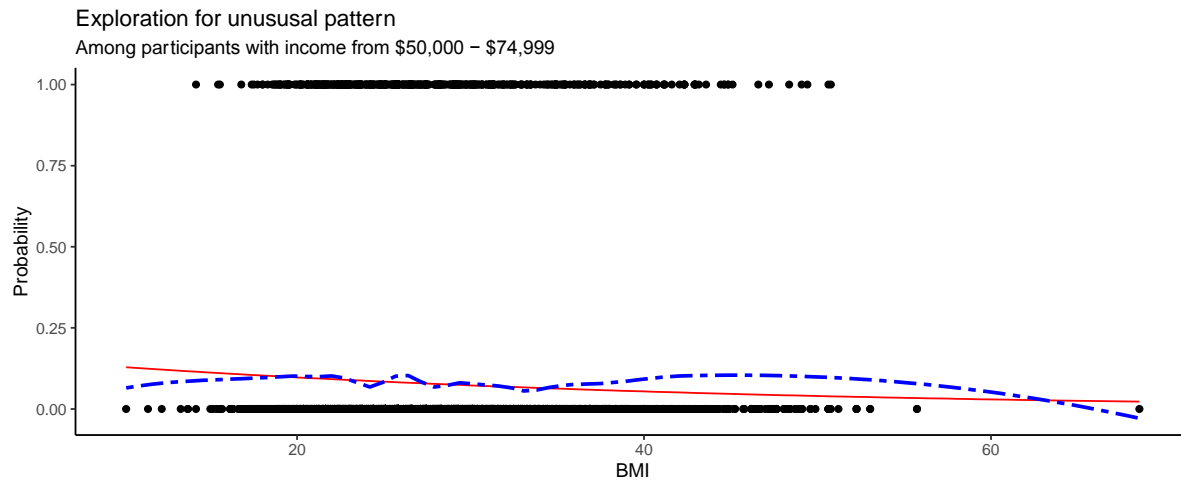
During data exploration, we found out unusual pattern in the distribution of subjects with income range from $50,000 to $74,999. A sub-analysis is conducted to investigate the possible reasons behind. Figure 5 suggests the similar pattern of probability among only participants with income from $50,000 to $74,999 between logistic and loess models. There is a subject with BMI higher than 60 which is considered as an outlier.