Relationship Between Alcohol Use and Obesity in US Adults Aged 20 to 79

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Abstract

Purpose: This is a secondary data analysis carried out to determine the association between alcohol use and obesity (BMI) in US adults aged 20 to 79 while adjusting for confounding factors that are known to affect obesity.

Methods: The 2017-2018 National Health and Nutrition Examination Survey (NHANES), was utilized to provide the sample of 22,565 adults between the ages of 20 and 79 who had a recorded BMI score. Multivariable regression was done to determine the association between obesity measured by the numerical variable BMI and average number of alcohol drinks taken by respondents in a day during the past year (numerical variable) while controlling for known demographic and socio-economic factors. These factors include age, sex, marital status, race, job, diet, number of people in household, physical activity, depression symptoms, smoking, health status, annual household income, education, sleep, sedentary activity, diabetes, number of meals from fast food and ratio of family income to poverty.

Results: The average BMI was higher in those who take heavy amounts of alcohol (5+) compared to those who take light (1-2) and moderate (3-4) amounts. The overall multivariable regression model showed that BMI was directly associated with number of alcohol drinks consumed in a day (β = 0.160kg/m^2; $p < .001$) after controlling for known confounding factors. Higher average BMI was seen in respondents who were less than 35 years, engage in vigorous activity, have diabetes and depressive symptoms, have less than $75000 annual household income and spend more time on sedentary activities while lower BMI was seen in males, those who were less than 3 in their households, people that maintain healthy diet, smokers, people with education not greater than high school, those with jobs and people who have good health and greater hours of sleep every day.

Conclusion: The direct association found in this study between obesity (measured by BMI) and number of alcohol drinks consumed is similar to findings in existing literature. Alcohol quantity is definitely a significant contributor in the prevalence of obesity.

Keywords: *Alcohol, obesity, sedentary activity, diabetes, depression, smoking*

1. Introduction to the Problem/Issue

Obesity is an important public health issue and affects over 300 million adults worldwide (Lourenço et al., 2012). A significant proportion of obese people live in developed countries with the US, UK, Mexico, and Greece having some of the highest BMI scores (Lourenço et al., 2012; Sayon-Orea et al., 2011). In most studies, obesity was defined as Body Mass Index (BMI) ≥ 30.0kg/m2 (overall obesity) and Waist Circumference (WC) > 88cm for women and > 102 cm for men (central or abdominal obesity) (French et al., 2010; Lourenço et al., 2012; O'Donovan et al., 2018; Sayon-Orea et al., 2011; Shelton & Knott, 2014; Traversy & Chaput, 2015; White et al., 2019). Obesity can be caused by so many factors which include psychological, genetic, environmental, dietary, physiologic, and pharmacologic factors (Lourenço et al., 2012).

A study by Traversy and Chaput (2015) explained that energy from alcohol appears to be additive to energy from other sources thus promoting a positive energy balance and ultimately weight gain. In addition, alcohol inhibits fat oxidation and thus monoxidised fat is preferentially deposited in the abdominal area (Lourenço et al., 2012). It also affects energy intake by suppressing the effects of leptin or glucagon-like peptide (GLP-1) (French et al., 2010).

Most studies grouped participants using the following characteristics: Age, sex, education, smoking status, energy intake, long-standing illness, sleeping habits, regular exercise, type of alcohol consumed, medication use, eating behavior, and socioeconomic status (French et al., 2010; Lourenço et al., 2012; O'Donovan et al., 2018; Tolstrup et al., 2005; Traversy & Chaput, 2015). According to Lourenço et al. (2012), Obese men and women were older, less educated, had lower energy intake, were less frequently smokers, and less physically active than non-obese men and women. Age was significantly associated with weight gain as was mental health, the number of hours watching TV, smoking cigarettes, and days per week of exercise

(Rohrer et al., 2005). Wine intake was found to be more likely to protect against weight gain whereas consumption of beer and spirits has been positively associated with obesity (Bobak et al., 2003; Sayon-Orea et al., 2011; Shelton & Knott, 2014). These factors make it particularly difficult to determine the independent influence of alcohol on obesity (French et al., 2010; Lourenço et al., 2012).

Several studies in adults have shown that the amount/intensity per drinking occasion is positively correlated with BMI (Traversy & Chaput, 2015). Drinking frequency was found to be inversely related to obesity; while it was unlikely that alcohol consumption had a direct beneficial effect on obesity, it was suspected that a report of no alcohol consumption may be a proxy for some other unknown variable that increases the risk of obesity (French et al., 2010; Rohrer et al., 2005; Tolstrup et al., 2005; Traversy & Chaput, 2015; White et al., 2019).

Another study showed that the association between drinking frequency and obesity was bell-shaped, with obesity risk not significantly different in those who drank most often and never drinkers (O'Donovan et al., 2018). For the same total intake of alcohol, daily drinkers were leaner than non-daily drinkers (French et al., 2010; Tolstrup et al., 2005). Heavy drinkers were more likely to be obese than light drinkers (Sayon-Orea et al., 2011; Traversy & Chaput, 2015). This study examines the association between alcohol intake and obesity in US adults between the ages of 20 and 79.

2. Methods

2.1 Study Population

This is a secondary data analysis of the 2017-2018 National Health and Nutrition Examination Survey (NHANES). NHANES is a repeated, cross-sectional survey of the civilian, non-institutionalized US population administered by the National Center for Health Statistics division of the Centers for Disease Control and Prevention and USDA. It utilizes a multistage, stratified area probability sampling design to select participants representative of the US population (Butler et al., 2018). The survey combines home interviews and physical examinations via a Mobile Examination Centre (MEC). The survey data are available on the internet for data users and researchers throughout the world. This study includes records for adults of ages 20 to 79 who had a valid response on the alcohol variable. There was a total of 22,565 adult participants between 20 to 79 who had BMI data and out of which only 16,572 had data on both BMI and average quantity of alcohol.

2.2 Exposure

The exposure in this study was quantity of alcohol consumed in a day. The questions were not specific to type of alcohol used. Quantity of alcohol consumption was analyzed using the question, "During the past 12 months, what was the average number of alcohol drinks you had in a day?" The variable name was ALQ130. The number of drinks was capped at 15. Thus, all responses of 15 or more drinks were recorded as 15. The variable was also recoded into a new ordinal variable with 3 categories – light (1-2), moderate (3-4), and heavy drinkers (5 or more).

2.3 Disease

The disease in this study was obesity. It was measured using Body Mass Index (BMI). The NHANES survey includes BMI as a previously computed variable BMXBMI. Obesity was defined as BMI of 30 or greater. This was later recoded as underweight/normal weight (BMI ≤ 24.9), overweight (25.0 – 29.9) and obese (30 or more).

2.4 Potential Confounding Variables

Age (Bobak et al., 2003; French et al., 2010; Lourenço et al., 2012; O'Donovan et al., 2018; Rohrer et al., 2005; Shelton & Knott, 2014; Tolstrup et al., 2005**)** was measured as a numeric variable (RIDAGEYR) and capped at 80. Adults 80 and above were grouped as 80. Only adults 20 to 79 were included in the study. This was recoded into 1 – 20 to 34; 2 – 35 to 64; 3 – 65 to 79.

Sex (O'Donovan et al., 2018; Rohrer et al., 2005; Traversy & Chaput, 2015; White et al., 2019) was measured as a nominal variable (RIAGENDR) - male and female.

Race (French et al., 2010; Rohrer et al., 2005) There were 6 categories of race in the variable (RIDRETH3) – Mexican American, Other Hispanic, Non-Hispanic White, Non-Hispanic Black, Non-Hispanic Asian, Other race – including multi-racial. This was first recoded as Hispanic, non-Hispanic White, non-Hispanic Black, non-Hispanic Asian and other race and then as 1 – white; 0 – not white

Marital Status (French et al., 2010; Rohrer et al., 2005) This was classified into 1 – Married, 2 – Widowed, 3 – Divorced, 4 – Separated, 5 - Never married, 6 - Living with partner. The variable name was DMDMARTL. This was recoded into a new binary variable 1 – partner and 0 – no partner.

Education (Bobak et al., 2003; French et al., 2010; Lourenço et al., 2012; Rohrer et al., 2005; Shelton & Knott, 2014; Tolstrup et al., 2005) The variable name was DMDEDUC2. This was classified as Less than 9th grade, 9-11th grade (Includes 12th grade with no diploma), High school graduate/GED or equivalent, Some college or AA degree and College graduate or above and then recoded first as less than high school, high school and greater than high school; and then into 1. high school or less and 0. greater than high school.

Number of people in household (French et al., 2010; Rohrer et al., 2005) This was measured as an ordinal variable (DMDHHSIZ): 1, 2, 3, 4, 5, 6 and 7 – 7 or more people in the household and recoded into 1. less than 3 and 0. 3 or more.

Annual household income (French et al., 2010; O'Donovan et al., 2018) participants annual household income was reported as an ordinal variable (INDHHIN2) with 12 categories. It was recoded into 1. less than $75,000, 0. $75,000 and above.

Smoking (Bobak et al., 2003; French et al., 2010; Lourenço et al., 2012; O'Donovan et al., 2018; Rohrer et al., 2005; Shelton & Knott, 2014; Tolstrup et al., 2005) The variable name was SMQ040. Participants reported if they smoked cigarettes every day, some days, or not at all. This was recoded as 1. Smoker; 0. Non-smoker

Physical activity (Bobak et al., 2003; Lourenço et al., 2012; O'Donovan et al., 2018; Rohrer et al., 2005; Shelton & Knott, 2014; Tolstrup et al., 2005; Traversy & Chaput, 2015) Respondents reported if they were physically active and were involved in vigorous work activity (PAQ605) which was reported as Yes and No. Also, respondents reported number of minutes of sedentary activity on a typical day (PAD680) as a numerical variable.

Current Job/business (French et al., 2010) The variable name was OCD150. Participants were asked the type of work done last week and were grouped into 4 categories - working at a job/business, With a job or business but not at work, Looking for work, or Not working at a job or business? This was recoded as 1 – Has job and 0 – No job

Depression (French et al., 2010; O'Donovan et al., 2018; Rohrer et al., 2005; Traversy & Chaput, 2015) The symptom items of the PHQ-9 scale were measured using the following question, "Over the last 2 weeks, how often have you been bothered by the following problems, Would you say..." (0) not at all, (1) sometimes, (2) often, and (3) all of the time. The nine items measured the following problems: (DPQ010) little interest or pleasure in doing things; (DPQ020) feeling down, depressed, or hopeless; [DPQ030] trouble falling or staying asleep or sleeping too much; [DPQ040] feeling tired or having little energy; [DPQ050] poor appetite or overeating; [DPQ060] feeling bad about yourself; [DPQ070] trouble concentrating on things; [DPQ080] moving or speaking slowly or too fast; [DPQ090] thoughts you would be better off dead. A summed score ranging from 0 to 27 was computed for all respondents with complete responses to these nine items. The overall score was then recoded into an ordinal variable with three categories: (1) 0 to 4 - Minimal or no risk for depression, (2) 5 to 19 - Moderately severe risk and (5) 20 to 27 - Severe risk for depression and then into a binary variable 1. Depression; 0. No depression.

Sleep (Traversy & Chaput, 2015) Respondents were asked, 'how many hours during the weekdays or workdays do you spend sleeping?' This was measured as a numeric variable (SLD012). The number of hours was capped at 14. All responses above 14 hours were recorded as 14. Also, all responses less than 3hrs were recorded as 2.

Socioeconomic status (French et al., 2010; O'Donovan et al., 2018) The variable name was INDFMPIR. It was measured as a numerical variable as the ratio of family income to poverty. It was then recoded into 1. Poverty (0 – 2.4); 0. No Poverty (2.5 – 5.0)

Diet (Tolstrup et al., 2005) Respondents were asked the number of meals obtained from fast food or pizza place (DBD900). These were measured as numeric variables 1 to 21 (Range of Values); 0 – None; 5555 - More than 21 meals per week; and recoded as a binary variable 1. 7 or more meals; 0. Less than 7 meals. Participants were also asked 'How healthy is your diet?' The variable name was DBQ700. To which they responded 1 – Excellent, 2 - Very Good, 3 – Good, 4 – Fair & 5 – Poor; and this was recoded into a binary variable 1. Healthy diet; 0. Unhealthy diet.

General health condition (O'Donovan et al., 2018; Traversy & Chaput, 2015) Respondents reported their general health condition as 1 – Excellent, 2 - Very good, 3 - Good, 4 - Fair, or 5 – Poor. The variable name was HSD010. It was then recoded as Excellent/Very good, Good and Fair/poor.

Chronic or long-standing illnesses (O'Donovan et al., 2018; Traversy & Chaput, 2015) Participants were asked questions that assessed if they have a long-standing illness like Diabetes, 'Doctor told you have diabetes?' The variable name was DIQ010. Respondent answered 1. Yes; 2. No; 3. Borderline and recoded into 1. Diabetes; 0. No diabetes.

2.5 Statistical Analysis

Quantity (Intensity) of alcohol was compared on relevant variables in terms of univariate statistics (percentage, means and standard deviation) as shown in Table 1. Initial bivariate analysis using Pearson χ^2 was used to identify the association between disease and exposure (light, moderate and heavy amounts of alcohol), and exposure and confounding factors. A One-Way ANOVA was used to compare the exposure groups (light, moderate and heavy) with Age, BMI, sleep (hours), minutes of sedentary activity, ratio of family income to poverty and depression risk score.

Pearson correlation R was conducted to test the relationship between BMI and average number of alcoholic drinks consumed in a day, age in years, depression risk score, minutes of sedentary activity, ratio of family income to poverty and sleep in hours and also between the exposure (average number of alcoholic drinks in a day) and the above variables too.

Then a simple unadjusted linear regression was performed to determine a respondent's BMI based on the average number of alcohol drinks consumed in a day. A multivariable linear regression model was carried out to predict the BMI from the average number of alcohol drinks in a day while controlling for demographic and socioeconomic confounding factors such as age, sex, marital status, race, job, diet, number of people in household, physical activity, depression symptoms, smoking, health status, annual household income, education, sleep hours, sedentary activity, diabetes, number of meals from fast food and ratio of family income to poverty.

The level of significance used was $\alpha = .05$. All statistical analyses were performed with IBM SPSS 25.0.

3. Results

The weighted 2017-2018 NHANES dataset included N=22,769 respondents who were aged 20 to 79. 22565 had valid data on BMI. Out of these number of respondents, only 16660 had a valid data on quantity/intensity of alcohol. Table 1 reports the valid total number and percentages for each variable and for each group under the categorical variables, and also the means and standard deviations for the numeric variables. The average age in the sample of 22,769 respondents was 46.8 years, with a standard deviation (SD) of 16.2 years. Of these, 11,045 (48.5%) were men and 11,724 (51.5%) were women.

Majority of the respondents were non-Hispanic White with a total number of 13,970 (61.4%) and had greater than high school level of education (14,091 or 61.9%). Almost two-thirds of the sample have partners (14,363 or 63.1%) and a little below half have annual household income above or equal to $75,000 (8,951 or 44.1%). 4,111 (42.9%) participants smoked, while 5,482 (57.1%) did not smoke at all.

About one-fifth of respondents reported fair or poor health. The average number of minutes participants spent daily watching TV or playing cards (sedentary activity) in a day was 349. The average number of hours spent by respondents sleeping was about 7.5 hours and the mean ratio of family income to poverty was 3.1. About two thirds of respondents have jobs and three-quarters had minimal to no risk of depression.

11.7% out of 16,660 respondents were heavy drinkers while about two-thirds reported taking light alcohol in a day. The average BMI was 29.9 (SD=7.4, median = 28.7); with 26.1% being underweight or with normal weight, 30.8% being overweight, and 43.1% obese.

Table 1. Descriptive Statistics for US Adults Ages 20-79

Variable	**N**	**Percent *or Mean (SD)***
Sex	22769	
Male	11045	48.5
Female	11724	51.5
Age % (years)	22769	46.8 (16.2)
20 to 34	6586	28.9
35 to 64	12425	54.6
65 to 79	3757	16.5
Marital status	22760	
Partner	14363	63.1
Race	22769	
White	13970	61.4
Household income (%)	20303	
< $75,000	11352	55.9
≥$75,000	8951	44.1
Education (%)	22753	
Less than High school	2485	10.9
High school / GED	6177	27.1
Greater than high school	14091	61.9
Smoking	9593	
No Smoker	5482	57.1
Smoker	4111	42.9
Health	21660	
Excellent/Very good	8776	40.5
Good	8746	40.4
Fair/Poor	4138	19.1
Ratio of Family Income to Poverty	20363	3.1 (1.7)
Minutes of sedentary activity in a day	22622	348.8 (203.1)
Current Job/business	22761	
Has job	15127	66.5
No job	7634	33.5
Depression score (%)	21526	3.2 (4.1)
None to minimal (0 to 4)	16207	75.3
Mild to moderate (5 to 19)	5162	24.0
Severe (20 to 27)	156	0.7
Quantity/Intensity of alcohol in a day	16660	
Light	11110	66.7
Moderate	3605	21.6
Heavy	1946	11.7
BMI (kg/m^2) (%)	22565	29.91 (7.36)
Normal/underweight	5885	26.1
Overweight	6954	30.8
Obese	9726	43.1

Table 2 shows the results of the crosstabulation analyses between the quantity of alcohol consumed and the variables relevant to the study. A one-way ANOVA was also done to identify the relationship between the numeric variables (Age, minutes of sedentary activity, BMI, depression scores, number of hours of sleep and ratio of family income to poverty). A Chi Square test identified that the differences in the proportions of male and females in the quantity of alcohol consumed was significant (χ^2 (2) = 975.0; p < .001). Males were more likely to consume larger quantities of alcohol than women (observed = 78%, expected = 49.8%).

There was also a significant association with quantity of alcohol among age groups (χ^2 (4) = 793.1; p < .001) with people aged 65 and above being less likely to take heavy amounts of alcohol ((observed = 4.8%, expected = 13.7%). Respondents who have partners were more likely to take less (light) alcohol than those without partners and this was statistically significant (χ^2 (2) = 186.4; p < .001). People with lower household income < 75,000 were more likely to take heavy amounts of alcohol than people with higher annual household income (χ^2 (2) = 144.6; p < .001). Education also had a significant relationship with quantity of alcohol consumed in a day (χ^2 (4) = 390.2; p < .001). People who had higher than high school education were less likely to take heavy amounts of alcohol (observed = 48.6 vs expected of 65.3) when compared to those with less than high school (observed = 15.5 vs expected of 8.2) and high school education (observed = 35.9 vs expected of 26.5).

Respondents who had jobs or businesses were more likely to take heavy amounts of alcohol than those without jobs (χ^2 (2) = 68.6; p < .001). Everyday smokers when compared to those that smoked some days or not at all were more likely to take heavy amounts of alcohol (χ^2 (4) = 575.5; p < .001). People with none to minimal risk of depression were more likely to take light alcohol and this was significant (χ^2 (4) = 180.6; p < .001).

Table 2. Characteristics of Adults Ages 20-79 by Quantity of Alcohol Consumption

Variable	Total	Quantity of alcohol			χ^2 /F	p
		Light	Moderate	Heavy		
Male (%)	49.8	42.2	57.9	78.0	975.0	<.001
Age (years) Mean (SD)	45.3(15.9)	47.9(16.0)	41.2(14.4)	38.4(13.9	473.9	<.001
Age groups (%)					793.1	<.001
20-34	31.8	26.1	41.1	47.2		
35-64	54.5	56.1	53.1	48.0		
65-79	13.7	17.8	5.8	4.8		
White (%)	64.1	66.0	62.2	57.1	63.9	<.001
Less than 3 in household%	44.1	46.4	40.0	38.2	75.2	<.001
Partner%	62.8	65.9	59.8	50.5	186.4	<.001
< $75,000 (%)	51.5	48.8	53.1	64.2	144.6	<.001
Education (%)					390.2	<.001
Less than High school	8.2	6.8	8.6	15.5		
High school / GED	26.5	23.7	30.1	35.9		
Greater than high school	65.3	69.5	61.3	48.6		
Current Job/business (%)					68.6	<.001
Job	71.2	69.1	74.7	76.2		
Smoking (%)					575.5	<.001
Every day	32.9	23.4	41.6	49.7		
Some days	10.5	8.0	12.2	15.7		
Not at all	56.7	68.6	46.2	34.5		
Health (%)					297.5	<.001
Excellent/Very good	42.6	46.2	37.5	31.6		
Good	39.9	38.8	42.9	40.4		
Fair/poor	17.5	14.9	19.6	28.0		
Diabetes (%)	11.3	12.4	9.0	9.3	40.4	<.001
Healthy diet (%)	27.7	31.3	23.8	14,5	270.1	<.001
≥7 meals from fast food%	6.2	5.6	5.8	10.1	52.8	<.001
Performs vigorous work%	30.1	25.2	35.7	47.6	465.3	<.001
Min. sedentary activity	354(203)	363(202)	347(205)	321(201)	37.9	<.001
Ratio of Fam. Inc to Pov.	3.2(1.6)	3.4(1.6)	3.1(1.6)	2.5(1.6)	241.6	<.001
Sleep in hours	7.5(1.4)	7.6(1.4)	7.4(1.4)	7.5(1.5)	31.4	<.001
Depression risk (%)					180.6	<.001
None to minimal (0-4)	75.8	78.7	71.0	68.2		
Mild to moderate (5-19)	23.4	20.7	28.4	30.0		
Severe (20-27)	0.7	0.6	0.7	1.8		
BMI (kg/m^2) Mean (SD)	30.0(7.4)	29.8(7.3)	30.0(7.6)	31.0(7.2)	22.6	<.001
BMI categories (%)					75.8	<.001
Normal/underweight	26.2	27.2	27.2	19.2		
Overweight	29.3	29.9	27.5	29.0		
Obese	44.5	42.9	45.4	51.7		

Whites were less likely to take heavy alcohol (observed = 57.1%, expected = 64.1%); $p < .001$. People who were less than 3 in their households were also less likely to take heavy alcohol ($p < .001$). Respondents who perform vigorous work were more likely to take heavy alcohol ($p < .001$). People who have fair/poor health were more likely to consume heavy amounts of alcohol (observed = 28.0 vs expected = 17.5) when compared to those that have excellent/very good and good health (χ^2 (4) = 297.5, $p<.001$).

Respondents who have been told they have diabetes were more likely to take light alcohol compared to those who have not been told (χ^2 (2) = 40.4, $p<.001$). Those that maintain a healthy diet were more likely to consume light quantities of alcohol compared to those who do not (χ^2 (2) = 270.1, $p<.001$). Participants that consume 7 or more meals from fast food/pizza were more likely to consume heavy alcohol (observed = 10.1 vs expected = 6.2, χ^2 (2) = 52.8, $p<.001$). Obese people were also more likely to drink large quantities of alcohol as seen in their observed vs expected (51.7 vs 44.5) and this was also statistically significant (χ^2 (4) = 75.8; $p < .001$).

A One-Way ANOVA was done to assess the difference in the ages of the three categories of alcohol quantity and the result was statistically significant (F (2, 16657) = 473.9; $p < .001$) with the light, moderate and heavy groups having an average age of 47.9 (SD = 16.0), 41.2 (SD = 14.4) and 38.4 (SD = 13.9) respectively. A Dunnett T3 post hoc test done showed that the three groups were significantly different between themselves in their mean age groups ($p < .001$). Older adults were more likely to take light alcohol.

Another One-Way ANOVA was done to assess the difference in the depression risk scores of the three categories of alcohol quantity and the result was statistically significant (F (2, 16612) = 72.8; $p < .001$) with the group that consumes heavy alcohol having the highest average score of 3.9 (SD=4.5), followed by the moderate group with an average score of 3.6 (SD=4.3) and then the light group with an average score of 2.9 (SD=3.9). A Dunnett T3 post hoc test done showed that the light group was significantly different from the other two groups ($p<0.001$), and the moderate and heavy groups were also significantly different from each other with a p-value of .032. Those who consume light alcohol have lower depression risk scores.

A third One-Way ANOVA also identified significant differences among the three alcohol quantity groups in their number of sleep hours ($F(2, 16571) = 31.4$, $p<.001$) with the light, moderate and heavy groups having an average sleep duration of 7.6 (SD=1.4), 7.4 (SD=1.4) and 7.5 (SD=1.5) hours respectively. A Dunnett T3 post hoc test carried out found that the light group was significantly different from the moderate ($p<.001$) and the heavy group ($p=.001$), but the moderate and heavy groups were not significantly different between themselves ($p=.125$). Respondents who take light alcohol have higher number of sleep hours.

A fourth One-Way ANOVA was done to assess the difference in the minutes of sedentary activity of the three alcohol quantity groups and the result was statistically significant ($F(2, 16548) = 37.9$; $p < .001$) with the light, moderate and heavy groups having an average of 362.8 (SD = 202.3), 347.3 (SD = 205.0) and 320.8 (SD = 201.2) minutes respectively. A Dunnett T3 post hoc test showed that the three groups were significantly different between themselves in their average minutes of sedentary activity ($p < .001$). Respondents with lower minutes of sedentary activity consume higher quantities of alcohol in a day.

A fifth One-Way ANOVA was done to assess the difference in the ratio of family income to poverty of the three categories of alcohol quantity and the result was statistically significant ($F(2, 15067) = 241.6$; $p < .001$) with the light, moderate and heavy groups having an average of 3.4 (SD = 1.6), 3.1 (SD = 1.6) and 2.5 (SD = 1.6) respectively. A Dunnett T3 post hoc test done showed that the three groups were significantly different between themselves in their mean ratio of family income to poverty ($p < .001$). Participants who have higher ratio of family income to poverty are more likely to take light alcohol.

Finally, a One-way ANOVA also identified significant differences across the three alcohol quantity groups in their average body mass index scores (F (2, 16569) =22.6, $p < .001$) with a higher average BMI in the heavy (31.0) and moderate groups (30.0) when compared to the group with light alcohol (29.8). Tukey post hoc test showed that the light (29.8 ± 7.34) and moderate groups (30.0 ± 7.56) are not statistically different from each other in their BMI scores ($p = 0.373$) but the group with heavy alcohol intake was significantly different from the other two ($p < .001$). People who consume larger quantities of alcohol have higher BMI scores.

The Pearson correlation test conducted found a weak positive correlation between BMI and average number of alcoholic drinks ($R = .019$, $p = .013$), age in years ($R = .044$, $p < .001$), depression score ($R = .077$, $p < .001$) and minutes of sedentary activity ($R = .122$, $p < .001$), a weak negative correlation between BMI and ratio of family income to poverty ($R = -.033$, $p < .001$) and sleep in hours ($R = -.044$, $p < .001$), a weak positive correlation between number of alcohol consumed and depression score ($R = .096$, $p < .001$) and a weak negative correlation between number of alcohol consumed and age ($R = -.224$, $p < .001$), minutes of sedentary activity ($R = -.079$, $p < .001$), sleep in hours ($R = -.044$, $p < .001$) and ratio of family income to poverty ($R = -.170$, $p < .001$).

A simple unadjusted linear regression was performed to determine a respondent's BMI based on the average number of alcohol drinks taken in a day and the result was found to be statistically significant, F (1, 16546) = 6.151; $p = .013$. For every extra alcohol drink taken by a respondent in a day, the BMI increases by 0.067kg/m². The total number of respondents in the unadjusted model was 16548. The linear regression equation for the unadjusted model is

$$Y'_{BMI} = 29.817 + 0.067*Number\ of\ alcohol\ drinks$$

The multivariable regression predicts the BMI from the average number of alcohol drinks in a day while controlling for demographic and socioeconomic confounding variables associated with obesity. All the variables in Table 2 were included in the regression analysis. The sample size for the multivariable analysis was 5,480.

Table 3. Multivariable Unstandardized Regression Coefficients

Variables	***Unstandardized Coefficients***	***Standard Error***	***t***	***p***
Constant	33.963	.709	47.887	<.001
Aver. # of alcohol drinks	0.160	.045	3.538	<.001
Male	-2.008	.212	-9.452	<.001
Partner	-0.317	.218	-1.455	.146
<3 in household	-0.646	.206	-3.140	.002
Healthy diet	-3.177	.254	-12.516	<.001
vigorous work	1.086	.219	4.960	<.001
7/more Fast food/Pizza in a week	-0.583	.446	-1.309	.191
Diabetes	4.739	.307	15.430	<.001
White	-0.920	.215	-4.273	<.001
Depression	0.779	.227	3.438	.001
Smoke	-2.629	.221	-11.891	<.001
Highschool or less	-0.579	.209	-2.775	.006
less than 75000	0.787	.276	2.848	.004
Job	-0.882	.232	-3.801	<.001
Good health	-1.442	.232	-6.221	<.001
Less than 35 years	0.706	.219	3.228	.001
poverty	-1.238	.280	-4.421	<.001
Minutes of Sedentary activity	0.006	.001	11.164	<.001
Sleep in hours	-0.239	.067	-3.580	<.001

$R^2 = 17.6\ \%$

The multivariable linear regression equation for the best model is

*Y'_{BMI} = 33.963 + 0.160*Number of Alcohol drinks + (-2.008)*Male + (-0.646)*less than 3 in household + (-3.177)*Healthy diet + 1.086*Vigorous work + 4.739*Diabetes + (-0.920)*White + 0.779*Depression + (-2.629)*Smoke + (-0.579)*High school or less + 0.787*Less than 75000 + (-0.882)*Job + (-1.442)*Good health + 0.706*less than 35years + 0.006*Sedentary minutes + (-0.239)*Sleep hours + (-1.238)*Poverty.*

This model (presented in Table 3) shows that BMI increases by 0.160kg/m² for every additional alcohol drink taken in a day. This was found to be statistically significant, $F(19, 5460) = 61.29$, $p < .001$; and explained 17.6% (R^2) of the amount of variation in BMI. After adjusting for all other variables in the equation, it can be seen that the BMI of males is on the average 2.008 lower than the BMI of females ($p<.001$). Individuals who live with just an additional person have an average BMI that is 0.646 lower than those who have 3 or more people in their households ($p=.002$). White people tend to have an average BMI that is 0.920 lower than non-white individuals ($p<.001$). Respondents who did not have education greater than high school have an average BMI that is 0.579 less than others with a higher level of education ($p=.006$).

People with Jobs have an average BMI that is 0.882 less than those without jobs ($p<.001$). Respondents with good health and those that maintain a healthy diet have an average BMI that is 1.442 ($p<.001$) and 3.177 ($p<.001$) less than their respective counterparts. People with annual household income less than $75,000 have an average BMI that is 0.787 greater than those with higher income ($p=.004$). Participants who have diabetes and those with risk of depression have an average BMI that is 4.739 ($p<.001$) and 0.779 ($p=.001$) more than those who do not have these respectively.

Respondents who are less than 35 years of age have an average BMI that is 0.706 higher than those who are older ($p=.001$). Those that participate in vigorous work have an average BMI that is 1.086 higher than those who do not ($p<.001$). Respondents who smoke have an average BMI that is 2.629 lower than those who do not smoke ($p<.001$). For every extra minute spent on sedentary activities such as watching TV or playing cards, the BMI increases by 0.006. Also, for each additional hour of sleep in a day, the average BMI reduces by 0.239kg/m^2.

Finally, having a partner ($p = .146$) and consuming 7 or more meals from fast food/pizza ($p = .191$) in a week did not have a significant association with BMI.

4. Discussion

This study examined the relationship between alcohol consumption and obesity while controlling for known confounders. There was a significant association between quantity of alcohol consumed in a day and obesity measured by BMI. This significant association between alcohol and obesity was maintained after adjusting for the confounding factors that are known to affect obesity. This is similar to existing literature such as in Shelton and Knott (2014), who found higher odds of obesity in respondents after adjusting for demographic, socioeconomic and lifestyle factors.

Another study by Tolstrup et al. (2005) found obesity to be positively associated with total drinks consumed but inversely associated with frequency of drinking. In French et al. (2010), the study found that increasing frequency and intensity (quantity) of alcohol use is significantly associated with small weight gain for men but not for women. Our study did not examine data for men and women differently.

Smoking was found to be associated with reduced BMI which was also similar to findings in several previous studies (Rohrer et al., 2005). This study also confirmed the relationship between risk of depression and obesity which is similar to findings by Rohrer et al. (2005). Persons who have significant risk for depression were more likely to engage in health behaviors predisposing them to obesity like reduced physical activity, increased sedentary lifestyle activities and consumption of unhealthy foods. Individuals with poor health are also more likely to develop obesity than other people. According to Traversy and Chaput (2015), sleeping less than 6 hours per night in adults is associated with greater alcohol intake and higher BMI. This is similar to our findings in this study.

There were some limitations in this study. In addition to being a cross sectional study, this study utilized self-reported data in number of alcohol drinks consumed in a day which may not be a true estimation of the actual number. Also, the differences in the different types of alcoholic drinks such as beer, wine and spirits were not accounted for. This has been shown in some studies like in Bobak et al. (2003) to have a significant influence on BMI.

5. Conclusions

The quantity of alcohol consumed in a day affect the BMI of an individual. Associations between obesity and depression has been seen in many studies. Primary health care workers may target obese people for depression screening.

Although smoking has been significantly linked to a less likelihood of obesity, individuals are advised to avoid using it as a weight loss strategy as smoking has been confirmed by many health professionals to have serious adverse effects on the body.

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