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ORIGINAL ARTICLE

Socioeconomic Status, Smoking, Alcohol use, Physical Activity, and Dietary Behavior as Determinants of Obesity and Body Mass Index in the United States: Findings from the National Health Interview Survey

Raees A. Shaikh, MD, MPH;[1]✉ **Mohammad Siahpush,** PhD;[1] **Gopal K. Singh,** PhD;[2] **Melissa Tibbits,** PhD[1]

[1]Department of Health Promotion, Social and Behavioral Health Sciences, College of Public Health, University of Nebraska Medical Center, Omaha, NE 68198-4365, USA

[2]The Center for Gloabal Health and Health Policy, Global Health and Education projects, Inc., Riverdale, MD 20738, USA.

✉Corresponding author email: raees.shaikh@unmc.edu

ABSTRACT

Objectives: The aim of this research was to study the socio-demographic and behavioral determinants of obesity and Body Mass Index (BMI) in the United States, using a nationally representative sample.

Methods: We used data from the 2010 US National Health Interview Survey. Analyses were limited to adults 18 years and older (N=23,434). Multivariate regression analyses were conducted to estimate the associations between covariates and obesity and BMI.

Results: Overall, 28.1% in the sample were obese and the mean BMI was 27.6 kg/m^2. In adjusted models, we found that older age, non-Hispanic Black race, lower education and income levels, Midwestern and Southern region of residence, former smoking, infrequent alcohol use, physical inactivity, consumption of less fruits, vegetables, brown rice and more cheese, fried potato and meat, were associated with obesity. These factors were also associated with higher BMI, along with male gender and higher consumption of meat, fried potatoes and cheese.

Conclusions and Global Health Implications: The association of many of the socio-demographic and behavioral factors with obesity and higher BMI found in our study was consistent with previous findings. Persistence of such associations suggest a need for better understanding of the underlying mechanism as well as for evaluation of the current programs and policies targeted at reducing the obesity burden in the United States. In view of the rising global obesity epidemic, especially in the low- and middle-income countries, our findings could help guide development of effective health and social policies and programs aimed at reducing the obesity burden in other parts of the world.

Key words: Obesity • Body Mass Index • Socioeconomic status • Physical activity • Diet • Smoking • Alcohol use • Disparity • United States • National Health Interview Survey

Introduction

A Body Mass Index (BMI) of 30 or greater is defined as obesity with a BMI less than 35 classified as Grade 1 obesity, BMI equal to or greater than 35 but less than 40 classified as Grade 2 obesity, whereas a BMI ≥40 categorized as Grade 3 obesity.[1] The risk of coronary heart disease, stroke, diabetes, and cancer increases with increasing BMI/obesity.[2] According to the World Health Organization (WHO), more than half a billion adults worldwide were obese in 2014, with the prevalence of obesity being four times higher in developed/high-income countries as compared to low-income countries.[3] Since 1980, the worldwide prevalence of obesity has more than doubled. A majority of world's population now lives in countries where being overweight and obese kills more people than being underweight.[3] Obesity rates have grown more rapidly in the industrialized countries than other regions of the world and recently the highest prevalence of obesity among the developed countries was seen in the United States (US) and Australia.[4] In the US, rising obesity rates have become a major public health issue, with more than one-third of adults in the US, i.e. 78.6 million people, being obese and the estimated annual cost of obesity reaching approximately $147 billion.[5,6] Such statistics in a developed nation with high levels of awareness about and efforts to control the obesity epidemic highlight the need for a thorough understanding of the determinants of rising BMI and obesity levels in the country.

As in other industrialized countries, studies have found differences in obesity prevalence across various socioeconomic, racial/ethnic, gender, and age groups in the US.[5, 7, 8] For example, overall prevalence of obesity is higher among blue collar workers than white collar workers.[5,7] Similarly, lower education, lower occupational status, and lower incomes have been associated with higher prevalence of obesity.[5,9,10] In terms of racial/ethnic disparities, non-Hispanic Blacks, American Indian/Alaska Natives, and Mexican Americans have the highest obesity prevalence in the US.[11,12] However, such socio-demographic determinants of obesity have hardly been studied recently taking into account certain important health behaviors associated with obesity.

The behavioral factors known to be associated with obesity include smoking, alcohol consumption, physical activity, and dietary habits.[13-16] Although there is not enough evidence to suggest that smoking leads to loss of weight or a steady state weight, it has been found that those who quit smoking are likely to gain weight and ex-smokers are more likely to be obese.[17,18] Alcohol consumption, especially heavy drinking, is linked with higher obesity prevalence,[15] so is poor quality diet containing less fruits and vegetables and more fats and sugars.[19] Many Americans are not meeting the dietary recommendations[19] as per the dietary guidelines issued by the United States Department of Agriculture.[20] Physical activity (PA) has also been established as one of the important predictors of weight gain with those getting enough PA, especially during leisure time, being less likely to be obese.[14,21] With modern working environments entailing prolonged sedentary work[22] and stresses of modern lifestyle cutting into leisure time, not many are able to achieve the recommended levels of PA, at job or during leisure.[21]

Previous studies have examined many of the important determinants of obesity. However, except for one study by Rohrer et al,[23] we were unable to find studies which have looked at the independent effect of all these possible socio-demographic and behavioral determinants. Rohrer et al primarily focused on determining how the frequency of alcohol use was related to obesity, taking into account age, cigarette smoking, PA, and health status.[23] However, the study participants were derived only from three community clinics in Texas, serving a predominantly lower socioeconomic population rather than a representative national sample. Literature is scarce on research examining variations in obesity or BMI across the possible determinants.

The purpose of this study was to examine the socio-demographic and behavioral determinants of obesity and BMI among adults in a national sample using data from 2010 National Health Interview Survey (NHIS). Our aim was to provide a comprehensive assessment of the current obesity and BMI disparities in the United States across racial/ethnic, socioeconomic, and many important behavioral factors.

Methods

We used data from the 2010 NHIS.[24] The NHIS uses multistage, cluster sampling and is primarily administered through direct in-person interviews. The household response rate for 2010 NHIS was 79.5%.[24] We limited our analysis to sample adults (≥18 years) for whom information on BMI and other variables of interest such as smoking was available. We excluded all observations in which information was missing for any of the variables being studied, except poverty status. The final sample size was 23,434.

The 2010 NHIS included BMI calculated for all persons who self-reported height and weight using the formula: BMI=weight in kilograms/height in meters squared. Obesity was defined as BMI>=30 kg/m^2.[1] Four socioeconomic covariates were considered: Education, occupation, poverty status, and home ownership. Poverty status was defined as the ratio of family income to the US federal poverty threshold. Demographic covariates included age, race/ethnicity, gender, and region of residence. These covariates were measured as categorical variables as shown in Table 1.

To determine smoking status, respondents were asked "Have you smoked at least 100 cigarettes in your entire life?" Those who replied affirmatively were asked "Do you now smoke cigarettes every day, some days or not at all?" Current smokers were defined as those who have smoked at least 100 cigarettes in their life and currently smoked every day or some days, former smokers as those who have smoked more than a 100 cigarettes in their life but do not currently smoke, and never smokers as those who have not smoked more than a 100 cigarettes in their life.

Alcohol consumption was categorized into six groups: (1) Never drinker who had consumed less than 12 drinks in lifetime; (2) former drinker who had consumed ≥12 drinks in lifetime but none in the past year; (3) current infrequent drinker with consumption of ≥12 drinks in lifetime and between 1 to 11 drinks in the past year; (4) current light drinker who had consumed ≥12 drinks in lifetime and ≤3 drinks per week in the past year; (5) current moderate drinker who had consumed ≥12 drinks in lifetime, and >3 drinks and up to 14 drinks per week in the past year among males, or >3 and up to 7 drinks per week in the past year among women; (6) current heavy drinker defined by ≥12 drinks in lifetime, and >14 drinks per week in the past year among males, and >7 drinks per week in past year among women.[25]

The variable for adherence to PA recommendations was computed based on a set of leisure-time physical activity questions which included frequency and duration of vigorous activities, frequency and duration of light or moderate activities, and frequency of strengthening activities. Responses to questions about vigorous and moderate activities were converted into minutes of these activities of 10 minutes or longer per week and the responses to strengthening activity questions were converted into frequency in times per week. These converted responses were then combined to create a variable to measure adherence to the PA recommendations. The 2008 US Department of Health and Human Services guidelines on PA,[26] recommend that adults should do at least 150 minutes a week of moderate-intensity, or 75 minutes a week of vigorous-intensity aerobic PA, or an equivalent combination of moderate- and vigorous intensity aerobic activity along with muscle-strengthening activities on 2 or more days a week.[26] Those who met these recommendations were distinguished from those who did not.

Respondents were asked to indicate how often during the past month they consumed any of the following food items: Fruit, 100% fruit juice, salad, other vegetables, beans, whole grain bread, brown rice, red meat, processed meat, fried potatoes, candy, cookies, donuts, ice cream, non-diet soda, and fruit drinks. For each respondent, we computed frequency of consumption of each food item per week. Food items such as salad, fruits, vegetables and fruit juice were grouped together as "fruits and vegetables". Candy, cookie, donut and ice-cream were combined together as "sweets". Similarly the "sugar sweetened beverages" group was created by adding soda and fruit flavored drink consumption. Finally, the food item group "meat" was created by adding red meat and processed meat consumption.

STATA 13.0 was used for the statistical analysis.[27] Weighted data were analyzed to report descriptive statistics as well as the distribution of obesity and mean BMI across different categories of the categorical

Table 1. Weighted Sample Characteristics, Percent Obese and Mean BMI (n=23,434)

Covariates	% in sample or mean (SD)[a]	% Obese[b]	p-value[c]	Mean BMI[d] (kg/m²)	p-value[e]
Total population	100.00	28.1		27.6	
Age (years)			<0.001		<0.001
18-24	12.9	18.8		25.5	
25-39	26.7	26.5		27.4	
40-54	28.2	32.7		28.4	
55+	32.1	29.3		27.8	
Gender			0.521		<0.001
Female	51.1	27.9		27.3	
Male	48.9	28.4		27.9	
Race/ethnicity			<0.001		<0.001
Non-Hispanic White	68.5	26.8		27.4	
Non-Hispanic Black	11.3	37.8		29.1	
Hispanic	13.9	31.4		28.3	
Other	6.2	18.2		25.8	
Years of education			<0.001		<0.001
Less than 9 years	4.9	30.2		28.2	
9-11 years	7.1	29.7		27.7	
12 years	28.1	31.6		28.1	
13-15 years	30.7	30.7		27.9	
16 or more years	28.9	21.2		26.6	
Occupation			<0.001		<0.001
Professional	19.6	26.2		27.3	
Sales/clerical/tech support	18.6	27.6		27.5	
Service	9.1	27.6		27.3	
Craft/repair	8.8	29.8		28.2	
Laborer	3.3	33.8		28.6	
Other	0.7	16.2		26.3	
Unemployed/not in labor force	39.6	28.8		27.6	
Poverty status			<0.001		<0.001
<100%	11.7	29.8		27.8	
100-199%	15.9	32.1		28.2	
200-299%	13.7	29.5		27.8	
300-399%	11.3	29.1		27.9	
400-499%	8.7	30.7		27.9	
≥500%	22.9	24.8		27.1	
Unknown	15.4	24.8		27.0	
Home ownership			0.896		0.841
Renter	30.6	28.1		27.6	
Owner	69.3	28.2		27.6	
Region			<0.001		<0.001
Northeast	17.5	25.7		27.2	
Midwest	23.1	30.3		27.9	

Contd....

Table 1. *(Continued....)*

Covariates	% in sample or mean (SD)[a]	% Obese[b]	p-value[c]	Mean BMI[d] (kg/m²)	p-value[e]
South	35.4	30.5		27.9	
West	23.8	24.6		27.1	
Smoking status			<0.001		<0.001
Current smoker	19.4	25.6		27.1	
Former smoker	21.9	32.6		28.3	
Never smoker	58.9	27.3		27.4	
Alcohol consumption status			<0.001		<0.001
Never	20.1	27.5		27.2	
Former	14.0	34.9		28.8	
Infrequent	13.6	34.8		28.5	
Light	31.1	26.6		27.4	
Moderate	15.7	22.9		26.8	
Heavy	5.2	20.1		26.6	
Adherence to PA recommendations			<0.001		<0.001
Yes	21.0	19.3		26.4	
No	78.9	30.5		27.9	
Fruit & vegetable consumption[f,g]	16.9 (11.7)	30.9/25.3	<0.001	28.0/27.2	<0.001
Sweets consumption[f,h]	5.6 (6.1)	29.6/26.5	<0.001	27.8/27.3	<0.001
Sugar sweetened beverage consumption[f,i]	4.1 (7.3)	26.5/29.8	<0.001	27.4/27.8	<0.001
Meat consumption[f,j]	4.5(4.2)	25.3/31.0	<0.001	27.1/28.1	<0.001
Fries consumption[f]	1.3 (2.0)	26.6/31.1	<0.001	27.4/28.0	<0.001
Whole grain bread consumption[f]	3.7 (4.0)	28.9/27.2	0.026	27.7/27.5	0.386
Brown rice consumption[f]	0.8 (1.9)	30.2/25.8	<0.001	27.9/27.3	<0.001
Cheese consumption[f]	3.7 (3.7)	27.6/28.7	0.135	27.5/27.6	0.016

[a]For continuous variables (i.e., frequency of consuming each food item per week), the mean and standard deviation of BMI is reported. [b]For continuous variables, the % obese for the category below the median and the category at or above the median, separated by a slash, are reported. [c]P-values for the association between obesity and each covariate. [d]For continuous variables, the mean BMI for the category below the median and the category at or above the median, separated by a slash, are reported. [e]P-value for the association of BMI and each covariate, [f]The food item variables indicate frequency of consumption per week. [g]This food category includes fruit, 100% fruit juice, salad, and other vegetables. [h]This food category includes candy, cookie, donut, and ice cream. [i]This food category includes non-diet soda and fruit drink. j This food category includes processed meat and red meat

covariates. Bivariate analysis was performed using logistic and linear regression to compute the unadjusted odds ratios and Beta coefficients for obesity and BMI, respectively. Multivariate logistic and linear regressions were performed to estimate the association of these covariates with obesity and BMI, respectively. To account for the complex sampling design of NHIS survey in all analyses, we took into account sampling weights, stratification, and primary sampling units in computations.

Results

Overall, 28.1% of the adults in the sample were obese and the mean BMI in the sample was 27.6 kg/m². Table 1 shows the weighted sample characteristics including obesity prevalence and mean BMI across different categories of the categorical covariates. For continuous variables of food item consumption, Table 1 shows obesity prevalence and mean BMI among those who consumed below and those who consumed at or above the median.

Significantly higher obesity prevalence and mean BMI were seen among those aged 40-54 years than other age groups, and among non-Hispanic Blacks than other racial/ethnic groups. Males had higher BMI than females (p<0.001). Those with a college degree had lower obesity prevalence and lower

BMI than those with lower educational attainment ($p<0.001$). Those working as laborers had higher obesity prevalence and BMI than those in other occupational categories. Individuals with family incomes at or above 500% of the poverty threshold ($11,137 for 1 person family, $14,216 for a family of 2, and $17,373 - $45,224 for families with 3 - 9 people for the year 2010) had significantly lower obesity prevalence and BMI than those at lower levels of income. Those residing in the South and Midwest of US had significantly higher obesity prevalence and BMI than those living in the Western US.

Higher obesity prevalence and mean BMI were seen among former smokers than current or never smokers, and among former alcohol drinkers than any other alcohol consumption category ($p<0.001$). Those who did not adhere to the PA recommendations had higher obesity prevalence and BMI than those who did ($p<0.001$). Lower consumption of fruits and vegetables ($p<0.001$), and consumption of brown rice ($p<0.001$) were associated with significantly higher obesity prevalence and BMI. On the other hand, higher consumption of sugar sweetened beverages, meat, and fried potatoes was associated with significantly higher obesity prevalence and BMI ($p<0.001$ for all associations). Lastly, lower consumption of whole grain bread ($p=0.026$) and higher consumption of cheese ($p=0.016$) were associated with higher obesity prevalence and BMI respectively.

Table 2 presents the unadjusted and adjusted odds ratios for the association of obesity with each of the covariates as well as the adjusted regression coefficients (expected mean difference in BMI) for the association of BMI with the covariates. The results of unadjusted analyses were consistent with the results in Table 1.

Results of the adjusted analysis were consistent with the unadjusted analyses for most of the covariates. Those aged 40-54 had higher odds of being obese and higher BMI (OR=2.38, $\hat{\beta}$=3.29) than those aged 18-24 years. Males had higher BMI ($\hat{\beta}$=0.58) than females. Non-Hispanic Blacks had higher odds of being obese and higher BMI (OR=1.62, $\hat{\beta}$=1.66) than non-Hispanic Whites. Individuals in all education categories had higher odds of obesity and higher BMI than those with ≥16 years of education. Individuals in all occupational groups (except laborers) had lower odds of obesity and lower BMI as compared to those in professional occupations once all other socio-demographic and behavioral differences were accounted for. Individuals with incomes below 500% of poverty threshold had higher odds of obesity and higher BMI than those living at ≥500% of poverty threshold. Those from the Midwestern and Southern US regions had significantly higher odds of being obese and higher BMI than living in the Western US. Gender and homeownership were not significantly associated with obesity.

Several of the hypothesized behavioral determinants were associated with obesity and BMI. The odds of obesity and BMI were higher among former smokers (OR=1.61, $\hat{\beta}$=1.42) than current smokers. Former and infrequent alcohol users were more likely to be obese (OR=1.19 and 1.31, respectively), whereas moderate and heavy alcohol users were less likely to be obese as compared to never drinkers. Those who did not adhere to the PA recommendation were more likely to be obese and had higher BMI (OR=1.51, $\hat{\beta}$=0.91) than those who did. Higher consumption of fruits and vegetables and brown rice was associated with lower odds of obesity and lower BMI. Increased meat, fried potato, and cheese consumption was associated with higher odds of obesity and higher BMI. Consumption of sugar sweetened beverages and whole grain bread were not significantly associated with obesity or BMI.

Discussion

The purpose of this study was to examine the socio-demographic and behavioral determinants of obesity and BMI in a national sample of adults in US. We found that old age, non-Hispanic Black race, 9-15 years of education, professional occupations, lower income, and Midwestern and Southern US region of residence were associated with higher adjusted odds of obesity and higher BMI. Behavioral factors such as former smoking status, infrequent alcohol use, and non-adherence to PA recommendations were also related to higher odds of obesity and higher BMI. Lower consumption of fruits and vegetables and brown rice and higher consumption of meat, fried potato and cheese was associated with higher odds of obesity and higher BMI.

Table 2. Regression of Obesity and BMI on Covariates (n=23,434)

Covariates	Unadjusted OR† (95% CI) of obesity	Adjusted* OR† (95% CI) of obesity	Unadjusted $\hat{\beta}$ coefficient (95% CI) for BMI	Adjusted* $\hat{\beta}$ coefficient (95% CI) for BMI
Age (years)				
18-24	1.00	1.00	0.00	0.00
25-39	1.55 (1.34, 1.80)	1.74 (1.48, 2.03)	1.95 (1.61, 2.29)	2.24 (1.88, 2.60)
40-54	2.09 (1.80, 2.34)	2.38 (2.01, 2.80)	2.96 (2.61, 3.32)	3.29 (2.91, 3.67)
55+	1.78 (1.54, 2.06)	2.03 (1.71, 2.39)	2.35 (2.02, 2.68)	2.77 (2.38, 3.15)
p-value	<0.001	<0.001	<0.001	<0.001
Gender				
Female	1.00	1.00	0.00	0.00
Male	1.02 (0.95, 1.09)	1.03 (0.96, 1.12)	0.55 (0.36, 0.74)	0.58 (0.39, 0.77)
p-value	0.521	0.337	<0.001	<0.001
Race/ethnicity				
Non-Hispanic white	1.00	1.00	0.00	0.00
Non-Hispanic black	1.66 (1.50, 1.83)	1.62 (1.46, 1.80)	1.74 (1.42, 2.07)	1.66 (1.33, 1.99)
Hispanic	1.25 (1.14, 1.36)	1.30 (1.16, 1.45)	0.90 (0.65, 1.14)	0.98 (0.70, 1.26)
Other	0.61 (0.52, 0.71)	0.69 (0.59, 0.81)	−1.58 (−1.96, −1.20)	−1.08 (−1.48, −0.69)
p-value	<0.001	<0.001	<0.001	<0.001
Years of Education				
Less than 9 years	1.60 (1.35, 1.90)	1.17 (0.97, 1.42)	1.62 (1.19, 2.05)	0.58 (0.11, 1.05)
9-11 years	1.56 (1.35, 1.81)	1.33 (1.12, 1.58)	1.09 (0.67, 1.51)	0.73 (0.28, 1.18)
12 years	1.71 (1.54, 1.90)	1.49 (1.33, 1.68)	1.57 (1.31, 1.83)	1.20 (0.93, 1.48)
13-15 years	1.64 (1.48, 1.82)	1.60 (1.43, 1.79)	1.36 (1.10, 1.62)	1.37 (1.11, 1.62)
16 or more years	1.00	1.00	0.00	0.00
p-value	<0.001	<0.001	<0.001	<0.001
Occupation				
Professional	1.00	1.00	0.00	0.00
Sales/clerical/tech support	1.07 (0.95, 1.20)	0.86 (0.76, 0.97)	0.13 (−0.19, 0.45)	−0.34 (−0.65, −0.03)
Service	1.07 (0.93, 1.23)	0.81 (0.70, 0.94)	−0.05 (−0.42, 0.31)	−0.75 (−1.12, −0.38)
Craft/repair	1.19 (1.04, 1.37)	0.79 (0.67, 0.92)	0.86 (0.50, 1.21)	−0.52 (−0.90, −0.13)
Laborer	1.43 (1.17, 1.76)	0.97 (0.77, 1.21)	1.28 (0.63, 1.93)	−0.06 (−0.70, 0.57)
Other	0.54 (0.34, 0.86)	0.44 (0.27, 0.71)	−1.05 (−1.83, -0.27)	−1.63 (−2.41, −0.85)
Unempl/not in labor force	1.14 (1.03, 1.25)	0.85 (0.75, 0.95)	0.27 (0.01, 0.53)	−0.49 (−0.77, −0.21)
p-value	<0.001	0.001	<0.001	<0.001
Poverty status				
<100%	1.28 (1.14, 1.44)	1.06 (0.92, 1.23)	0.73 (0.40, 1.07)	0.45 (0.07, 0.83)
100-199%	1.43 (1.28, 1.60)	1.16 (1.02, 1.31)	1.10 (0.79, 1.40)	0.61 0.28, 0.94)
200-299%	1.27 (1.13, 1.42)	1.02 (0.90, 1.15)	0.75 (0.44, 1.06)	0.22 (-0.09, 0.53)
300-399%	1.24 (1.09, 1.41)	1.04 (0.91, 1.18)	0.81 (0.45, 1.17)	0.36 (0.02, 0.69)
400-499%	1.30 (1.12, 1.51)	1.16 (0.99, 1.36)	0.73 (0.40, 1.19)	0.49 (0.11, 0.87)
≥500%	1.00	1.00	0.00	0.00
Unknown	1.00 (0.88, 1.13)	0.87 (0.76, 0.99)	−0.01 (−0.30, 0.27)	−0.28 (−0.56, −0.00)
p-value	<0.001	<0.001	<0.001	<0.001

Contd...

Table 2. *(Continued...)*

Covariates	Unadjusted OR† (95% CI) of obesity	Adjusted* OR† (95% CI) of obesity	Unadjusted $\hat{\beta}$ coefficient (95% CI) for BMI	Adjusted* $\hat{\beta}$ coefficient (95% CI) for BMI
Home ownership				
Renter	1.00	1.00	0.00	0.00
Owner	1.00 (0.93, 1.08)	0.98 (0.90, 1.07)	0.02 (−0.19, 0.23)	−0.10 (−0.33, 0.12)
p-value	0.896	0.772	0.841	0.363
Region				
Northeast	1.05 (0.93, 1.20)	1.08 (0.95, 1.23)	0.09 (−0.23, 0.43)	0.15 (−0.16, 0.47)
Midwest	1.31 (1.17, 1.46)	1.21 (1.07, 1.37)	0.75 (0.43, 1.07)	0.52 (0.19, 0.84)
South	1.34 (1.21, 1.48)	1.16 (1.05, 1.30)	0.75 (0.48, 1.03)	0.31 (0.04, 0.58)
West	1.00	1.00	0.00	0.00
p-value	<0.001	0.008	<0.001	0.011
Smoking status				
Current smoker	1.00	1.00	0.00	0.00
Former smoker	1.40 (1.25, 1.58)	1.61 (1.43, 1.82)	1.18 (0.87, 1.48)	1.42 (1.10, 1.74)
Never smoker	1.09 (0.98, 1.20)	1.34 (1.20, 1.50)	0.29 (0.02, 0.57)	1.01 (0.72, 1.30)
p-value	<0.001	<0.001	<0.001	<0.001
Alcohol consumption status				
Never	1.00	1.00	0.00	0.00
Former	1.40 1.25, 1.57)	1.19 (1.05, 1.34)	1.53 (1.20, 1.85)	0.85 (0.52, 1.19)
Infrequent	1.40 (1.24, 1.57)	1.31 (1.15, 1.49)	1.25 (0.88, 1.63)	0.97 (0.60, 1.34)
Light	0.95 (0.86, 1.04)	0.97 (0.87, 1.08)	0.18 (−0.08, 0.44)	0.16 (−0.11, 0.44)
Moderate	0.78 (0.69, 0.88)	0.79 (0.69, 0.92)	−0.38 (−0.69, −0.07)	−0.45 (−0.79, −0.11)
Heavy	0.66 (0.55, 0.79)	0.63 (0.51, 0.77)	−0.67 (−1.07, −0.27)	−0.70 (−1.12, −0.28)
p-value	<0.001	<0.001	<0.001	<0.001
Adherence to PA recommendations				
Yes	1.00	1.00	0.00	0.00
No	1.83 (1.66, 2.01)	1.51 (1.36, 1.68)	1.52 (1.31, 1.74)	0.91 (0.69, 1.13)
p-value	<0.001	<0.001	<0.001	<0.001
Fruit & vegetable consumption	0.98 (0.98, 0.99)	0.98 (0.98, 0.99)	−0.03 (−0.04, −0.02)	−0.02 (−0.03, −0.02)
p-value	<0.001	<0.001	<0.001	<0.001
Sweets consumption	0.99 (0.98, 0.99)	0.98 (0.97, 0.98)	−0.02(−0.03, −0.01)	−0.04 (−0.06, −0.03)
p-value	0.001	<0.001	<0.001	<0.001
Sugar-sweetened beverage consumption	1.00 (1.00, 1.01)	1.00 (0.99, 1.00)	0.02 (0.00, 0.03)	0.00 (−0.00, 0.02)
p-value	<0.001	0.111	<0.001	0.214
Meat consumption	1.03 (1.02, 1.04)	1.03 (1.02, 1.04)	0.10 (0.07, 0.13)	0.08 (0.06, 0.11)
p-value	<0.001	<0.001	<0.001	<0.001
Fries consumption	1.03 (1.01, 1.04)	1.02 (1.00, 1.04)	0.08 (0.03, 0.13)	0.05 (0.00, 0.10)
p-value	<0.001	0.018	<0.001	0.037
Wholegrain bread consumption	0.99 (0.98, 0.99)	0.99 (0.98, 1.00)	−0.009 (−0.03, 0.01)	0.01 (−0.01, 0.03)
p-value	0.041	0.773	0.386	0.283
Brown rice consumption	0.92 (0.89, 0.94)	0.95 (0.93, 0.97)	−0.18 (−0.23, −0.14)	−0.11 (−0.16, −0.07)
p-value	<0.001	<0.001	<0.001	<0.001

Contd...

Table 2. *(Continued...)*

Covariates	Unadjusted OR† (95% CI) of obesity	Adjusted* OR† (95% CI) of obesity	Unadjusted $\hat{\beta}$ coefficient (95% CI) for BMI	Adjusted* $\hat{\beta}$ coefficient (95% CI) for BMI
Cheese consumption	1.00 (1.00, 1.01)	1.02 (1.01, 1.03)	0.03 (0.00, 0.05)	0.07 (0.03, 0.10)
p-value	0.031	<0.001	0.016	<0.001

*Adjusted for all covariates, †OR=Odds ratio

In general, our findings regarding age, racial/ethnic, and regional patterns in obesity were consistent with those found in previous studies.[8, 28,29] Consistent with previous research, we found higher likelihood of obesity and higher BMI among non-Hispanic Blacks than any other racial/ethnic group in both unadjusted and adjusted analyses.[5,11] The exact etiology behind these racial/ethnic differences is unknown. However, this finding needs to be interpreted with caution since BMI is used here as a measure of obesity. Previous research has found racial/ethnic differences in the degree of adiposity at a given BMI level,[30-33] with non-Hispanic Blacks having higher lean mass and lower fat mass as compared to non-Hispanic Whites at the same BMI level. Although BMI is known as a standardized measure of obesity, it does not represent adiposity directly.[29] Thus, the racial/ethnic differences found in our study may not necessarily correspond to differences in fat mass or percentage of body fat.

In both unadjusted and adjusted analyses, lower levels of education and incomes were generally associated with higher likelihood of obesity and higher mean BMI. These findings are consistent with previous research showing higher obesity and BMI among those at lower levels of socioeconomic position.[5,9,10] However, in the adjusted models, those in professional occupations had higher likelihood of obesity and higher BMI than those in non-professional occupations, somewhat inconsistent with the patterns seen in previous studies.[5,9,10] Diet, total energy intake, physical activity, sedentary life styles, and other health-risk behaviors might explain much of the observed socioeconomic differences in obesity and BMI and are known to act as proximate, intervening variables in the relationship between socioeconomic status and obesity.[5] Thus, the comparison of unadjusted and adjusted models indicates that dietary factors, PA, and other socio-behavioral factors largely explain education, occupation, and income/poverty influences on obesity and BMI shown here.

Consistent with previous findings, we found that former smokers were more likely to be obese and had higher BMI as compared to current smokers.[13,17,18] These previous studies had claimed that quitting smoking was associated with weight gain which is further corroborated by the fact that between 1970 and 2002 the obesity rate for Americans has more than doubled,[34] and during the same period, the smoking rate has declined by more than 10%.[13] In our study, even never-smokers had higher odds of being obese and higher BMI as compared to current smokers. Many of the smokers who attempt to quit, claim weight gain as the reason for their adopting smoking again.[35] Although exact mechanism of the association between smoking cessation and weight gain is unknown, many of the smokers do gain weight upon quitting, which is why providing weight management resources along with help in quitting is necessary for the success of cessation as well as weight management programs.[36]

In case of alcohol consumption, we found that current infrequent alcohol users had higher odds of being obese and higher BMI as compared to never users, which was inconsistent with previous findings by Rohrer et al[23] who found lower odds of obesity among current infrequent drinkers, and Arif et al[15] who had found that the heavy alcohol users were more likely to be obese as compared to never users. In fact, we found the lowest odds of obesity and lowest BMI among heavy drinkers. Arif et al had used 1988-1994 NHANES data,[15] whereas the Rohrer study used data collected from patients of clinic serving predominantly low socioeconomic group population.[23] Differences in data collection, time periods, and population along with adjustment for multiple covariates different from the ones in our study, might explain the inconsistency in our findings. As increased alcohol consumption has been found to be associated with poor diet,[37] we performed additional analysis (not shown here) and found that heavy alcohol consumption was indeed significantly associated with higher consumption of unhealthy food items, such as fries and sweets and lower consumption of fruits and vegetables. Yet, our results suggest a possible confounding effect of other factors on the relationship between alcohol consumption, poor diet and obesity. This interesting finding needs to be explored further, possibly using anthropometric measurements and longitudinal data.

We also found non-adherence to PA recommendation to be associated with higher odds of obesity and higher BMI, which was consistent with previous findings.[14,21] Lack of PA contributes to the imbalance between energy intake and expenditure and predisposes one to weight gain.[34] Also contributing to the energy imbalance, we found that dietary habits such as lower consumption of fruits, vegetables, and brown rice and higher consumption of cheese, fries and meat, were associated with higher likelihood of obesity and higher BMI. This finding was consistent with previous research;[19] however an interesting finding in our study was that of higher consumption of sweets such as candy, cookies, donuts and ice cream, being associated with lower odds of obesity as well as lower BMI. This finding was consistent in both bivariate and multivariate analyses and should be further explored in future studies.

Our study has limitations. Many of the measures used in our analysis including height and weight used for calculating BMI and obesity, PA, dietary habits, smoking and alcohol consumption status were all self- reported. Although BMI as a measure of obesity correlates with fat distribution, it does not measure percent body fat and it does not account for those with predominantly muscular build.[7] Also, as stated earlier, while self-reporting, there is a general tendency to over-report height and under-report weight and those who are heavier are more likely to under-report their weights.[38] Despite this, BMI based on self-reported height and weight is considered a valid measure of obesity.[39] Similarly, smoking and alcohol consumption are likely to be underreported,[40,41] whereas leisure time PA might be either under or over-reported.[42] However, the validity of self-report smoking, self-report alcohol consumption as measures of smoking, alcohol use and PA level has been established.[43,44] Self-report bias in reporting dietary habits are well known,[45] and thus associations of dietary factors with our outcomes must be interpreted with caution. Finally, the cross-sectional nature of the NHIS data only allows for reporting the association of the covariates with our outcome of interest and does not permit establishment of causation.

Conclusions and Global Health Implications

our study is one of the few studies that have tried to shed light on the determinants of obesity and BMI while accounting for a wide range of socioeconomic, demographic and behavioral factors together. Using data from a recent and nationally representative survey with a high response rate, we were able to report the disparities in obesity and BMI across different covariates. Many of our findings were consistent with previous findings reiterating the association of factors such as age, race/ethnicity, education, occupation, region, smoking status, alcohol consumption, PA, and dietary habits with weight gain. Such evaluations of disparities in obesity on a continued basis, not only helps policy makers and public health professionals to monitor the progress of their efforts but also lets them make changes, if required, into the direction and focus of their interventions. Persistent racial/ethnic inequalities in the distribution of obesity and BMI call for more targeted and innovative approaches to better understand and reduce such disparities.

Given the association of lower socioeconomic status with obesity, public health programs should aim at reaching this subpopulation at an early stage, educating and empowering the children from lower socioeconomic groups so that their disadvantages do not accompany them into adulthood. Healthy habits such as physical activity, healthy diet, and abstinence from tobacco and alcohol, should be instilled in early life in order to achieve long-term health benefits. Re-energizing the physical education program in public schools could be a good start. Additionally, access to healthy food choices could be improved for the socioeconomically disadvantaged population through programs such as community gardens, fresh produce markets, access to physical activity resources and other interventions targeting the environmental factors affecting energy balance. It is only when public health policies and programs at the population level are able to compliment the medical healthcare services at the individual level that we would be able to achieve a reduction in the huge morbidity and mortality burden of obesity.

Our study findings have implications for many low- and middle-income countries facing the rising obesity epidemic. Besides the health and economic impact, obesity has many social and psychological consequences both at the individual and societal level,[46] which makes it immensely important to develop public health programs that could help avoid the adverse social and health consequences of an uncontrolled epidemic. Such consequences are likely to be particularly detrimental to the low-income and middle-income countries. In view of the rising obesity levels in developing countries, the development of successful policies and programs that effectively address the obesity epidemic in high-income countries is essential in order to serve as guide for these countries to be better prepared to face the challenges that they are likely to encounter. Similar to the socio-economic disparities in obesity, risk factors such as poor diet and physical inactivity are also no longer restricted to those in high-income countries[47] This suggests that the developed countries, with their abundant resources, could help lead and guide these efforts to achieve the desired global health objectives in terms of reducing obesity as well as the associated social inequalities. Our results could help provide insights into the development of policies and programs that could be expanded and adapted to the needs of low- and middle-income countries struggling with rising obesity rates. Until there is a strong policy action to reduce inequalities in socioeconomic conditions and behavioral risk factors, the global obesity epidemic is likely to continue.

Ethical Approval: *No IRB approval was required for this study, which is based on the secondary analysis of a public-use federal database.* **Financial Disclosure**: *None to report.* **Funding/Support**: *None.* **Conflicts of Interest**: *None.*

Key Messages

- Overweight and obesity are among the top 5 leading risk factors of mortality in the world. 28.1% US adults were obese in 2010 with a mean BMI of 27.6 kg/m^2. These rates keep rising and the obesity prevalence in the US now exceeds 30%.
- Non-Hispanic Blacks, those residing in the Midwestern and Southern United States, and those with lower education, income, and occupational status had higher likelihood of obesity and higher BMI than others. Former smokers were more likely to be obese and had higher BMI than current smokers, indicating that providing weight management resources along with help in quitting is necessary for the success of cessation as well as weight management programs.
- Non-adherence to physical activity and lower consumption of fruits, vegetables, and brown rice and higher consumption of cheese, fries and meat were associated with higher likelihood of obesity and higher BMI.

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