A Case of *Double Jeopardy* in the Obesity Epidemic

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ABSTRACT: As a result of the rapid prevalence of overweight and obesity experienced nationwide over the course of the past three decades, substantial research has been appropriately devoted to understanding the nuanced social mechanisms by which obesity disproportionately impacts particular sub-populations of the United States. However, the distinctions and health implications stratified by class of obesity, especially in its most extreme construct remains a rather unexplored epidemiologic challenge. The framework behind this study is the theory of double jeopardy, which contends that being minority status in addition to being older acts as "multiple hazards" to one's health, where the aggregate impacts of aging in addition to racial discrimination generates the most deleterious health consequences for minorities in their later years. Using continuous data from NHANES, logistic regression and predicted probability model results suggest that the interaction of African American and Mexican and obesity yields elevated risks for hypertension compared to obese Whites. Furthermore, older African Americans and older Mexicans exhibit extremely steep probabilities for hypertension compared to older Whites, thus warranting the double jeopardy hypothesis.

INTRODUCTION

Over the course of the past three decades, the United States has exhibited an accelerated prevalence of overweight and obese, thus emerging into an "obesogenic environment", where unhealthy, processed, and fast foods are sensationalized and the consumption of excess calories coupled with a lack of physical activity are promoted.

From the early 1970s to 2000, the average adult body mass index increased from approximately 24.9 (normal weight) to 27.9 (overweight) (Wang et al.) Consequently, in 2004, approximately 65% of adults were either overweight or obese, and about five years from today, that figure is projected to increase approximately to an alarming 75% of adults being overweight or obese (Wang, et al., Stein, et al.) More importantly, along with this subsequent increase in body weight, arrives a multitude of adverse health consequences, with the most common co-morbidities being: Cardiovascular Disease, Hypertension, Type 2 Diabetes Mellitus, Coronary Heart Disease, Metabolic Syndrome, Stroke, and certain types of cancers (Wang et al., Thompson et al.)

Although the very fundamental underpinnings of obesity are undeniably fathomed and established by researchers, namely being the simultaneous behaviors of excess calorie consumption and lack of physical activity, the particular mechanisms by which obesity, ethnicity, gender, socioeconomic status, and age are associated is very complex and nuanced. Consequently, there has been very substantial research particularly in the last decade to delve into the multi-faceted complexities of obesity, yet very little research has been devoted to the particular distinctions and health implications stratified by class of obesity, especially in its most extreme forms.

Therefore, to further investigate this growing epidemic issue of obesity and its intersection with ethnicity, this study will examine the specific health outcome of hypertension when stratified by class of obesity, and its intersection with ethnicity (minority status). Furthermore, this study will examine the double jeopardy theory to explore the effect of age on hypertension for minority individuals.

LITERATURE REVIEW: THE RELEVANCE OF OBESITY IN THE UNITED STATES

Some of the complexities involved with disentangling the direct and indirect pathways of obesity can be attributed to the role of two polar elements of genetics and physical environment. Identical twin studies indicate that there is simultaneous weight gain experienced by individual twins when they were placed on high calorie diets for approximately 100 days (Pi-Sunyer 2002). Similarly, a study of body weights of adoptees indicates that adoptee children resemble the BMIs[1]of their biological parents, as opposed to the BMIs of their adoptive parents (Pi-Sunyer 2002). However, there is also considerable evidence that the physical environment plays a crucial role in catalyzing the stimulation of overweight and obesity. In a study of Pima Indians, those who reside in urban, affluent areas in metropolitan Arizona were found to have higher BMIs compared to the Pima Indians residing in the rural regions of Mexico abiding by their traditional standards of diet (Pi-Sunyer 2002).

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[1] Body mass index as defined by the Center for Disease Control, the World Health Organization, and the National Heart, Lung, and Blood Institute is: **BMI = mass (kg)/height (m^2)**

*Figure 1 depicts the respective weight categories defined by the CDC, WHO and NHLBI according to body mass index for adults.

The environmental factors that stimulate and induce obesity have developed only over the past few years, in which super sized food items and fast foods have become sensationalized and promoted (Hill et al. 1998). Experiments testing very high fat diets on animals convey that body fat in mice increased directly and proportionally when placed under high fat dietary schemes (Hill et al. 1998). Behavioral studies also show that certain behavioral patterns can give rise to obesity. In a supermarket study conducted by Westerterp, individuals who purchased foods with full fat exhibited higher average calorie intake and thus higher weight gain than individuals who purchased reduced fat foods (Hill et al. 1998).

Although the controversies of whether genetics or environment attributes more salience in predicting obesity are still being debated, the most significant underpinning of the obesity epidemic is that obesity is rapidly increasing at alarming rates; consequently, individuals are exceedingly being impacted by the detrimental health consequences of it. Not only has the proliferation of overweight as well as obesity led to approximately 300,000 deaths nationwide, excess amounts of weight gain yields elevated risks for chronic conditions such as: renal failure, metabolic disorders, dyslipidemia, hyperinsulinemia, gallbladder disease, and other cardiovascular morbidities (Rahmouni et al. 2004). Previous studied also show that there lies a stronger relationship between obesity and these chronic health conditions than the association between these chronic conditions and other high-risk behaviors, such as smoking and drinking (Hill et al. 2003).

Epidemiologic investigation clearly shows that weight gain is directly associated with increased risks for hypertension, and controlled laboratory experiments on animals provide evidence that weight gain deposited as fatty tissue as a result of high fat, high sodium diets yields high blood pressure (Hall et al. 2004).

In the Nurses' Health study of nurses ages 38 to 63, the relative risk of hypertension for women with higher BMI increased to about 4.8 compared to normal weight women, and this risk was diminished as BMI decreased (Pi-Sunyer, 2002). Furthermore, Thompson and Edelsberg use data from the third wave of the National Health and Nutrition Examination Survey as well as the Framingham Heart Study to model the relative risks of hypertension by BMI ranges. They report that for a BMI of 22.5, the relative risk for hypertension is 26.7, and for a BMI of 27.5 and 32.5, the relative risks for hypertension increase to 38.1 % and 50.1%

LITERATURE REVIEW: DOUBLE JEOPARDY

The double jeopardy theory contends that being a minority in addition to being older acts as multiple hazards to one's health, where the cumulative effects of aging in addition to racial discrimination will yield deleterious health consequences for minorities, particularly in later life (Ferraro et al. 1996). Therefore, the disadvantages cumulated throughout the life course by minorities become translated into vast health disparities after lifelong experiences with racial discrimination, lack of adequate access to proper healthcare, and substantial lack of social capital (Ferraro et al. 1996). However, out of all of the minority groups, the capacious chasm that exists between African Americans and non-Hispanic whites in terms of health and mortality is the most explicit in form (Hummer 1996). Hummer contends that individual level racial discrimination is the most crucial element that can be attributed to this white-black American health divergence, as isolation, harassment, and disadvantage, in both inconspicuous and explicit forms, ultimately affect stress, mortality, and morbidity for African Americans (Hummer 1996).

The requisite to fulfill the double jeopardy hypothesis is twofold: first, the minority group must exhibit poorer health with respect to the majority (white) group, and secondly, the effect of age must generate steep adverse health consequences for minorities than for whites (Ferraro et al. 1996); therefore, both the main effects of age and ethnicity as well as the interaction effects of age and ethnicity must be found to be statistically significant to confirm the double jeopardy hypothesis (Carreon, Noymer)

The application of the double jeopardy theory have been previously confirmed and reexamined in several cases. Dowd and Bengtson hypothesized that either double jeopardy, or the age as leveler theory would be exhibited for older minorities in their study consisting of a cross sectional data set (Dowd et al. 1978). In stark contrast to the double jeopardy theory, the age as leveler theory, as explored by Dowd and Bengtson, posits that minorities at older ages are in advantageous positions than older whites, since older age bestows upon minorities physical incompetence and physical disadvantage that has a diminishing effect on the ramifications of racial discrimination (Dowd 1978). Furthermore, the age as leveler theory postulates that minorities adapt to the racial discrimination that they face throughout their early years of life, in such that they regard age discrimination in a more tactful manner in their later years (Dowd 1978). In their cross sectional study design, Dowd and Bengtson find mechanisms of double jeopardy to be operant for older African Americans and Mexican American Americans aged 45 to 74 (Ferraro et al. 1996). Additionally, in a study utilizing data from the California Health Interview Survey, Carreon confirms double jeopardy by using a negative binomial regression model for only African Americans and Hispanics when using mean number of days in poor physical health as the outcome measure of health and physical well—being (Carreon, Noymer). However, the effect of the double jeopardy hypothesis has been refuted in a study conducted by Ferraro, where the varying effect of age had no results on the disparate health outcomes for older whites and older African Americans (Ferraro 1987). The disaffirmation of the double jeopardy hypothesis in Ferraro's 1987 study may be a consequence of social inequalities, racial discrimination, and a lack of social capital manifested in earlier life that endures a leveling effect throughout the life course (Ferraro 1987).

These previous studies include as dependent outcome measures respondents' self reported health; however, this study will specifically use hypertension (coded by the blood pressure variable) as one measure of health, which is directly collected by the data set utilized for this study.

DATA AND METHODS

The data used for this paper comes from the National Health and Nutrition Examination Survey Continuous 2003-2004, 2005-2006, 2007-2008 data sets. NHANES is a quality survey design with two significant advantages: first, it is a cross sectional survey designed to be nationally representative, and secondly, it utilizes and implements a mobile examination clinic to directly take health and body measurements. This becomes a prominent advantage in this particular study, since previous research has shown that individuals do tend to over report their height and under report their weight (Palta, et al). To adjust for the complex survey design, sampling weights provided by the National Health and Examination Survey's Analytic and Reporting Guidelines were utilized.

The method of analysis to perform the study is logistic regression, where hypertension is a dichotomous outcome variable defined as having a systolic blood pressure greater than or equal to 140, or a diastolic blood pressure of greater than or equal to 90, or currently being on prescription drug therapy to treat hypertensive conditions (0=not hypertensive, 1=hypertensive). The dependent variable of hypertension was specifically chosen for two main criteria: first, it is the gateway condition to cardiovascular disease, which is the leading cause of death in the United States, and secondly, the blood pressure measure variable was a variable directly taken by NHANES. (In fact, both systolic and diastolic blood pressures were taken three times each per respondent, and the average of the three each for systolic and diastolic blood pressure was utilized) Moreover, both systolic as well as diastolic blood pressure was directly measured three times each per respondent, which eliminates biases and reporting error. Furthermore, a sub population of individuals age 20 and over were specified in the regression models, as NHANES classifies individuals aged 20 and over as adult; also, focusing this particular analysis on adults would standardize the procedures of BMI and body weight categories, since BMI for children is frequently based on percentile rankings.

The independent variables include the basic socio-demographic variables of: age, gender, ethnicity, education, income, and smoking. These variables were then broken down into dummy variables, with the exception of age, which was treated continuously. For education levels, the reference group is high school graduates, for ethnicity, the reference group is whites, for income, the reference group is medium household income (approximately $44,000), and for smoking, the reference group is non-smokers. Variables of Class 1, Class 2, and Class 3 Obesity were generated according to their respective BMIs so that each odds ratio could be obtained for each weight class, using normal weight as the reference group.

RESULTS

Age adjusted prevalence rates were calculated for each class of obesity in order to show the discrepancy of prevalence when stratified by age and ethnicity. Using figures from the 2000 US Census, age ratios of proportion over total in each age group were utilized to obtain the adjusted measures. In Figure 3 and Figure 4, we can see that the Class 1 obesity rates are approximately equally distributed between each ethnic group and age group, especially amongst Whites, African Americans, Mexican Americans, and other Hispanics, with the other ethnic category exhibiting the lowest proportions of Class 1 obesity. In Figure 5 and Figure 6, we can see that again, the prevalence rates for Class 2 obesity are equally distributed, with the exception of the other ethnic category, namely, Multi-racials, Asians, and Pacific Islanders. Additionally, we can see that individuals aged 50 and over exhibit slightly higher prevalence rates than individuals aged 20-49. However, for the most extreme class of obesity, Class 3 obesity, every ethnic group faces a substantial decline in prevalence across each age group with the exception of African Americans (Figure 7 and Figure 8). Not only do African Americans have the highest prevalence rates compared to the other ethnic groups, for the most extreme case of obesity, they actually exhibit approximately equal prevalence rates for Class 2 and Class 3 obesity. When the age adjusted prevalence rates are aggregated, African Americans have the highest prevalence rates for each class of obesity, and therefore overall, followed by Mexican Americans and Whites (Figure 9).

Regression Model 1 from Figure 12 shows the odds ratios for Class 1, Class 2, and Class 3 obesity when gender, age, smoking, ethnicity, and socioeconomic status (measured by income and education) are controlled for. The logistic regression results yield interesting findings: from each subsequent jump from Class 1 to Class 2 to Class 3 obesity, the odds ratios exhibit a doubling pattern, as they increase from 1.65, 2.94, and 6.19, respectively. Therefore, at the very extreme levels, for Class 3 obesity, the odds ratio of having hypertension are 6.19 as large than the odds for a normal weight individual in terms of having hypertension.

When considering the interaction effects of obesity and minority (Figure 12, Model 2), the effect of Class 1 obesity was found to be statistically significant for only African Americans and Mexican Americans, when holding the basic socio-demographic variables constant. Both the main effects of Class 1 obesity and minority (African Americans and Mexican Americans) as well as the interaction term of Class 1 obesity and minority (African Americans and Mexican Americans) were found to be statistically significant. Thus, for a African American with Class 1 obesity, the odds ratio of hypertension are 1.38 as large than the odds ratio for obese Whites, and for a Mexican American with Class 1 obesity, the odds ratio of being Hypertension are 1.73 as large than the odds ratio for Class 1 obese Whites. Similarly, as conveyed in Model 2 of Figure 12, the effect of Class 3 obesity was found to be statistically significant for only African Americans and Mexican Americans, with Class 3 obese and minority yielding odds ratios of 1.57 and 2.14, respectively, giving Mexican Americans with Class 3 obesity odds ratios twice as large as the odds ratio for Class 3 obese Whites. However, although the odds ratios for the main effects of African American (0.52) and Mexican American (0.22) were found to be statistically significant, the interaction effects of Class 2 obesity and minority were not statistically significant.

Because the presence of an interaction term distorts the interpretation of the main effects, which are found to be negative in this case, (African American and Mexican main terms), a predicted probability model was utilized to capture both the effects of the main terms and interaction terms. The effect of Class 1 and Class 3 obesity on minorities accrues very elevated predicted probabilities for hypertension, when mean values of age, socioeconomic status, and non-smoking status were used to calculate the predicted probabilities. Figure 10 conveys the respective predicted probabilities for hypertension for Class 1 obese and Class 3 obese African Americans and Mexican Americans. For both of these classes of obesity, African Americans have the higher predicted probabilities, with a 89% predicted probability for a Class 3 obese African American being hypertensive. However, in these predicted probability models, Mexicans show a greater increase of probability of hypertension from Class 1 to Class 3 obesity, increasing from 47% to 85%.

To statistically test for the double jeopardy theory, age and minority interactions were included in the third regression model in Figure 12. The interaction terms of age and African American and age and Mexican were found to be statistically significant with odds ratios of 1.02 and 1.02, respectively. Furthermore, the main effects of age (1.07), African American (0.51) and Mexican (0.23) were found to be statistically significant, when controlling for the basic socio-demographic variables as well as each class of obesity. Indeed, through this regression model, older African Americans and older Mexican Americans exhibit significantly greater risks in having hypertension than older Whites, thus illustrating and validating the double jeopardy theory. To demonstrate the double jeopardy theory in operation, a predicted probability model was incorporated using mean values of age, socioeconomic status, and non-smoking status. The graphical representation of the minority and age interaction effects reaffirms the double jeopardy hypothesis conveyed in Figure 11. In the predicted probability model in Figure 11, we can see that at the earlier ages, Whites actually have a higher probability of being hypertensive compared to African Americans and Mexicans, but at the older ages, the converse takes effect. The significantly steep slopes for African Americans and Mexicans compared to the smaller slopes for Whites convey their relatively immense risks for hypertension.

CONCLUSIONS, LIMITATIONS, AND IMPLICATIONS FOR FUTURE RESESARCH

The intersection between obesity and minority is extremely nuanced, especially when classified and distinguished by each class of obesity; this association exhibits divergent health consequences for minorities, namely African Americans and Mexicans compared to Whites. By using logistic regression to analyze the specific health risk of hypertension, a doubling pattern of odds ratios was found from each advance from Class 1 to Class 2 to Class 3 obesity.

Furthermore, the effect of being both obese and African American and Mexican was found to significantly increase the probability of being hypertensive compared to obese whites only for Class 1 and Class 3 Obesity. When taking into account age and minority interaction effects, older Mexicans and older African Americans were found to have very elevated predicated probabilities of hypertension, confirming the double jeopardy theory.

One of the crucial limitations in this particular study is the application of cross sectional data as opposed to panel data, which becomes a significant issue in differentiating between cohort and non-cohort experiences. Additionally, body mass index, as measure of weight status,

BMI (x)	**Class of weight**

is a rough proxy for inference in body fat distribution as a measure of health, and studies show that body mass index coupled with waist to hip circumference ratios together act as better indicators of body fat distribution; however, waist to hip circumference ratios alone do not suffice as measures of health and body fat distribution (Janssen et al. 2004).

The issue of childhood obesity could be an area of interest for future research and the application of cumulative disadvantage theory, where disadvantages manifested in the early years will lead to significant disparities with age for particular cohorts (Ferraro et al. 2003). Also, the issue of triple jeopardy theory can be applied by taking into account the variable of gender with its intersection of age and minority status to further delve into the nuance manifested in health inequality.

x < 18.5	Underweight
18.5 ≤ x < 25	Normal weight
25 ≤ x < 30	Overweight
30 ≤ x < 35	Class 1 Obese
35 ≤ x < 35	Class 2 Obese
x ≥ 40	Class 3 Obese

FIGURE 1. BODY MASS INDEX AS DEFINED BY THE CDC, WHO, NHLBI

FIGURE 2. DESCRIPTIVE STATISTICS ADULTS 20+

DESCRIPTIVE STATISTICS : NHANES 2003-2008	
Mean BMI	28.5
Percent normal weight	29.86%
Percent over weight	37.39
Percent Class 1 Obese	20.74%
Percent Class 2 Obese	7.57%
Percent Class 3 Obese	4.44%

FIGURE 3. AGE ADJUSTED PREVALENCE RATES: CLASS 1 OBESITY

Age	African American	Mexican	White	Hispanic	Other
20-29	20.5	19.7	14.2	22.1	11.7
30-39	22.1	23.1	21.0	20.1	20.1
40-49	22.2	20.6	22.1	22.1	20.8
50-59	24.2	28.0	21.6	20.8	15.0
60-69	24.2	31.0	22.2	26.3	15.2
70+	24.3	17.1	18.2	23.6	10.7

FIGURE 4. AGE ADJUSTED PREVALENCE RATES: CLASS 1 OBESITY

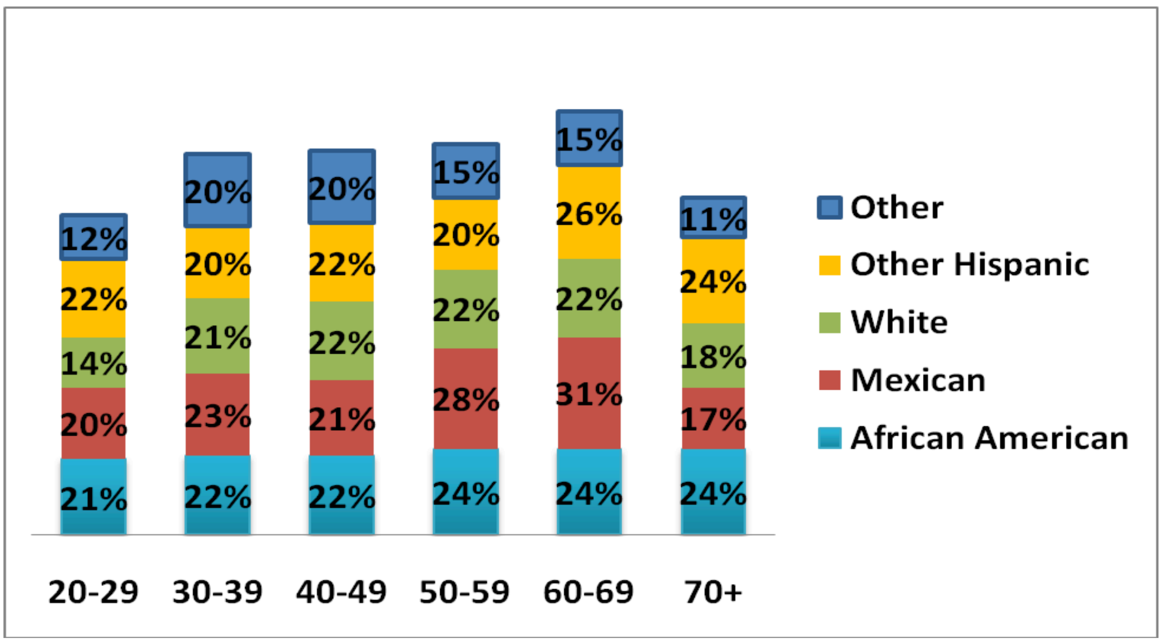


FIGURE 5. AGE ADJUSTED PREVALENCE RATES: CLASS 2 OBESITY

Age	African American	Mexican	White	Hispanic	Other
20-29	6.9	4.8	5.2	7.0	0
30-39	8.0	6.0	5.5	7.2	3.1
40-49	6.0	6.7	7.5	13.3	10.5
50-59	10.3	9.8	10.9	4.6	2.5
60-69	14.4	9.4	9.7	6.5	3.5
70+	11.4	6.6	5.6	2.2	3.8

FIGURE 6. AGE ADJUSTED PREVALENCE RATES: CLASS 2 OBESITY

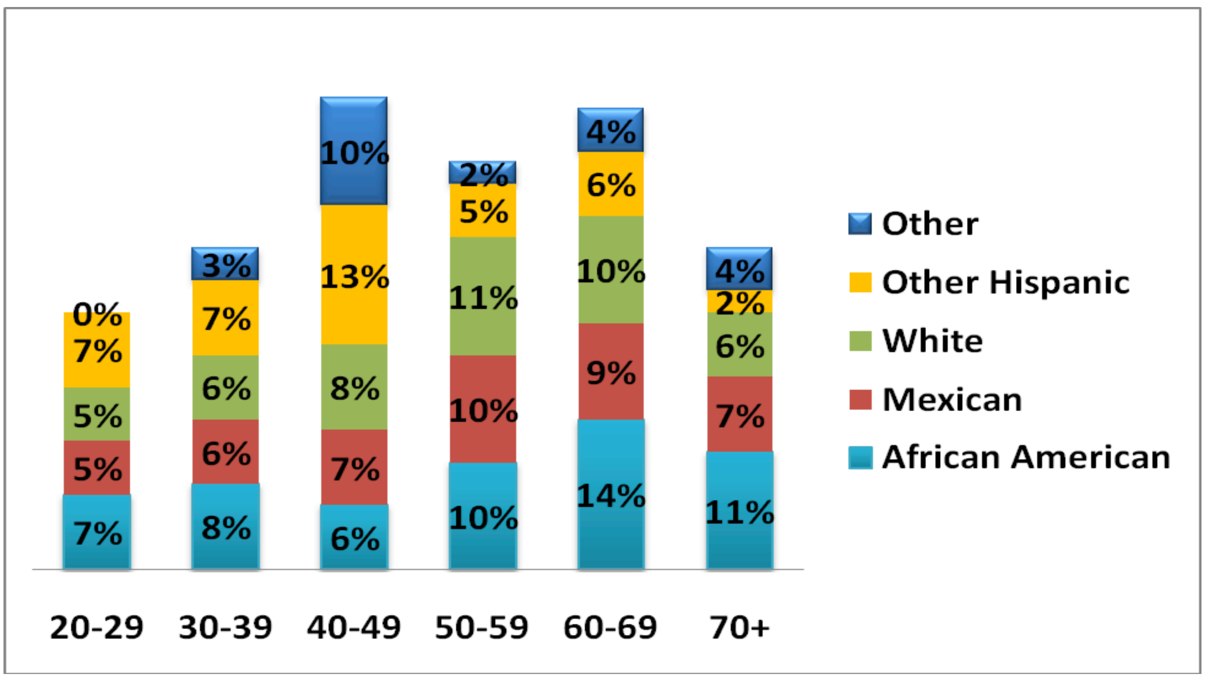


FIGURE 7. AGE ADJUSTED PREVALENCE RATES: CLASS 3 OBESITY

Age	African American	Mexican	White	Other Hispanic	Other
20-29	7.4	4.1	3.6	2.3	0
30-39	8.3	4.8	3.0	1.3	1.7
40-49	7.3	4.0	4.4	3.0	.60
50-59	12.4	4.2	5.2	6.4	5.9
60-69	10.2	3.5	5.5	2.1	2.1
70+	4.4	3.9	2.4	1.2	0

FIGURE 8. AGE ADJUSTED PREVALENCE RATES: CLASS 3 OBESITY

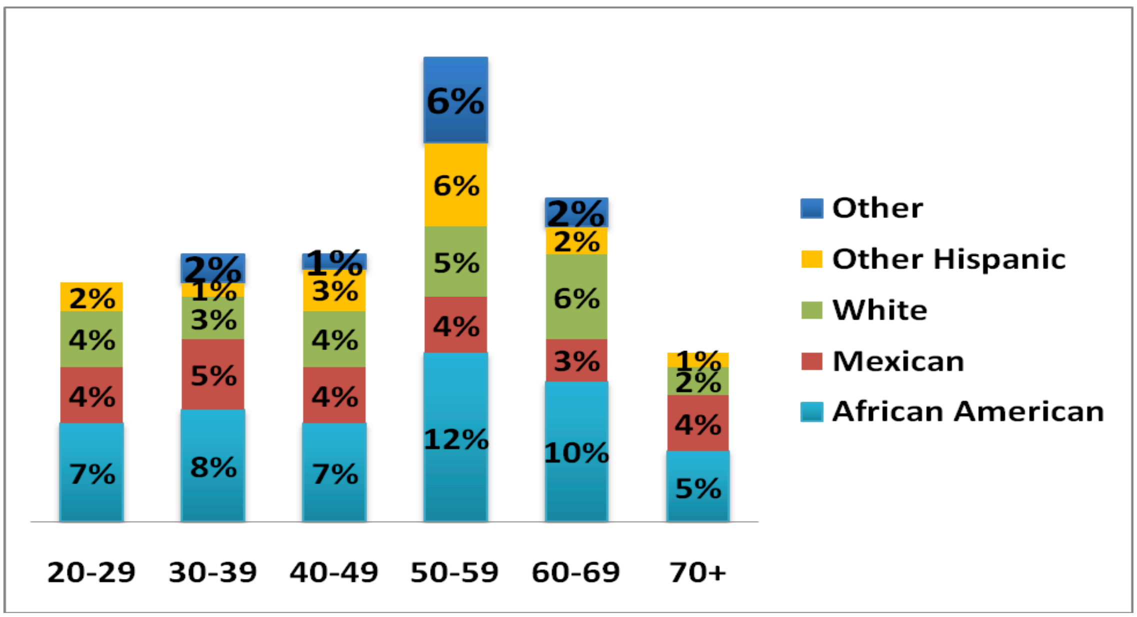


FIGURE 9. OVERALL PREVALENCE RATES BY CLASS OF OBESITY AND ETHNICITY

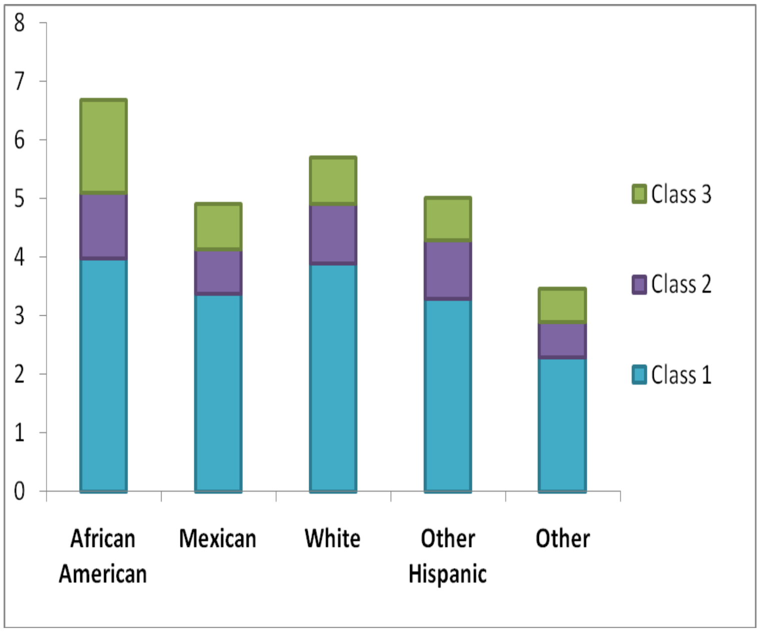
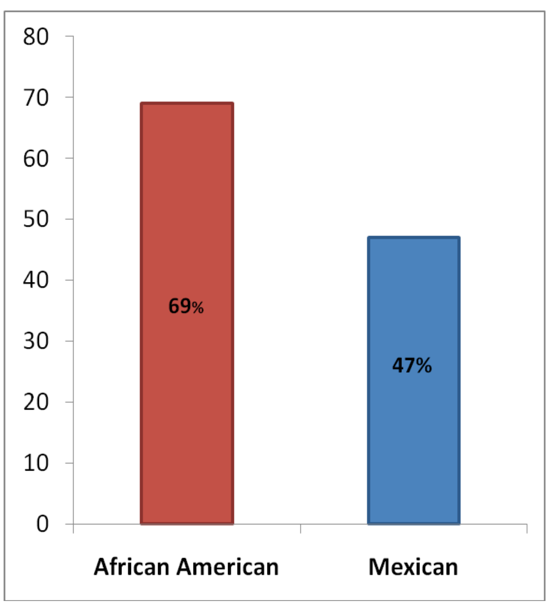


FIGURE 10. PREDICTED PROBABILITIES OF OBESITY AND MINORITY

Class 1 Obese and Minority



Class 3 Obese and Minority

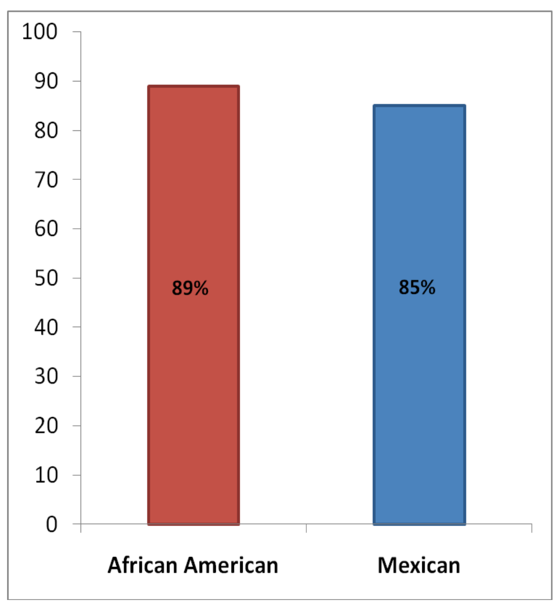


FIGURE 11. PREDICTED PROBABILITY OF HYPERTENSION: AGE AND MINORITY INTERACTION EFFECTS

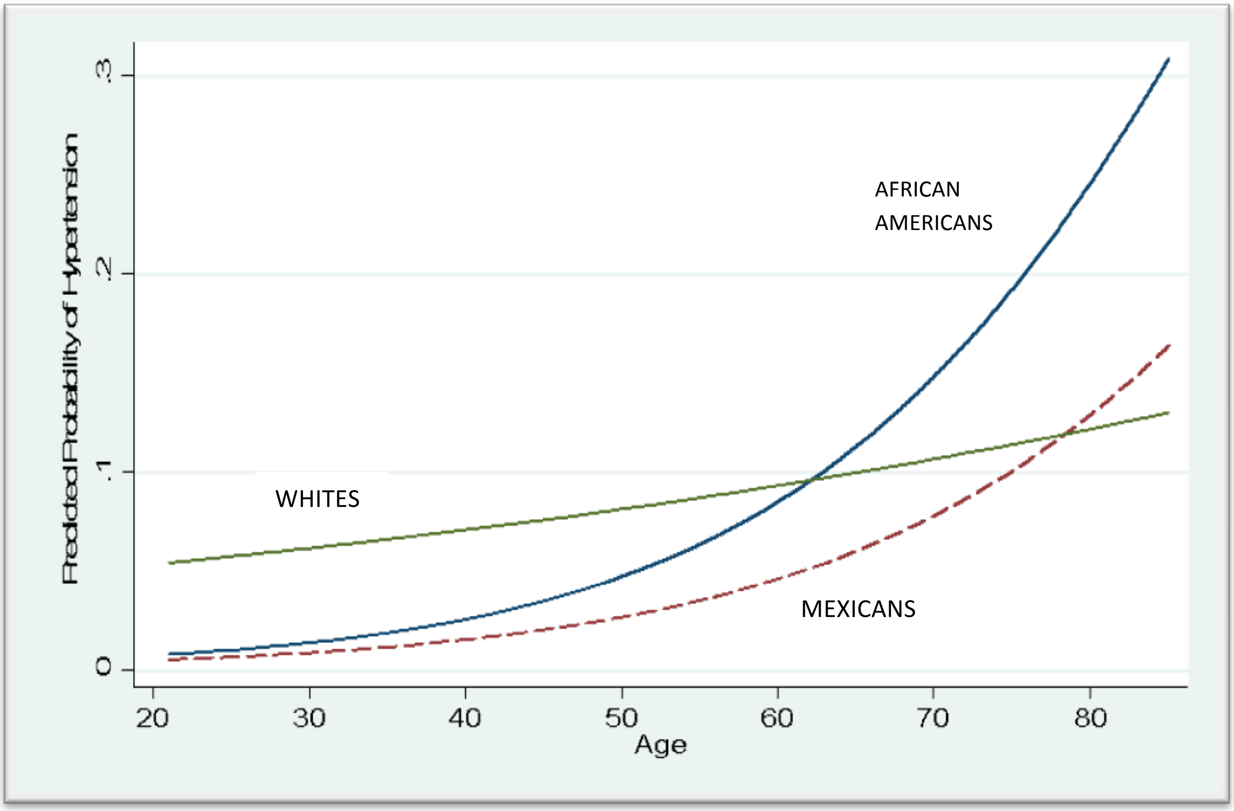


FIGURE 12. LOGISTIC REGRESSION: ODDS RATIOS FOR HYPERTENSION	MODEL 1	MODEL 2	MODEL 3
INDEPENDENT VARIABLES	**Hypertension**	**Hypertension**	**Hypertension**
female	.98	.99	.99
age	1.08***	1.07***	1.07***
age2	1.00*	1.00	1.00
smoking	1.06	1.07	1.07
ETHNICITY (Reference Group=White)			
Af. Am.	1.53***	.52**	.51**
Mexican	.66***	.22***	.23***
Other Hispanic	.83	.54	.56
Other	1.07	.47	.48
OBESITY (Reference Group=Normal Weight)			
Class 1 obese	1.65***	1.50**	1.49**
Class 2 obese	2.94***	2.73***	2.70***
Class 3 obese	6.19***	5.05***	5.01***
EDUCATION (Reference Group= High School GED)			
Less than high school	1.15	1.16	1.14
College graduate	.70***	.88***	.73***

HOUSHOLD INCOME (Reference Group=modern income)			
Low income (<$35,000)	1.06	1.06	1.17
High income (>$75,000)	1.03	1.03	1.16
OBESITY X ETHNICITY INTERACTIONS (Reference group=classobese X white)			
class1obese X Af.Am.		1.38**	1.37**
class1obese X Mexican		1.73***	1.73***
class1obese X Other Hispanic		1.11	1.11
class1obese X Other		1.86	1.83
class2obese X Af. Am.		1.11	1.10
class2obese X Mexican		1.37	1.36
class2obese X Other Hispanic		1.41	1.38
class2obese X Other		.79	.75
class3obese X Af. Am.		1.57*	1.57*
class3obese X Mexican		2.14**	2.08**
class3obese X Other Hispanic		.54	.55

AGE X ETHNICITY INTERACTIONS (Reference Group= Age X White)			
Age X Af. Am.			1.02***
Age X Mexican			1.02***
Age X Other Hispanic			1.00
Age X Oher			1.01
OBSERVATIONS	N=17467	N=17467	N=17467

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