

## **SOCIO-ECONOMIC FACTORS IN DISEASE RATES: A LONGITUDINAL STUDY OF OBESITY, DIABETES AND HEART DISEASE IN MISSISSIPPI**

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### **Abstract:**

Obesity is among the leading causes of many chronic medical conditions such as diabetes and heart disease. This longitudinal study examined the associations between obesity, diabetes, and heart disease in the state of Mississippi in 2005 - 2017. It used the Behavioral Risk Factor Surveillance System (BRFSS) data published by the Center for Disease Control and integrated social economic data of individuals from Mississippi in 2005 - 2017. Socioeconomic factors like race, gender, level of education, and household income affect chronic disease rates considerably. Data analysis of disease rates showed that obesity and cardiovascular disease are directly related. Risk of a cardiovascular condition is higher for Caucasians, male, low education, and low household income groups.

*Keywords— Obesity, Diabetes, Heart Disease, Socio Economic Factors, Public Health*

## 1. INTRODUCTION

The Center for Disease Control (CDC) has identified that chronic diseases are the leading causes of death and disability and the leading drivers of the \$3.3 trillion annual healthcare cost in the United States. Six in ten adults in the U.S. has a chronic disease and four in ten adults have two or more chronic diseases. Diabetes and heart disease are among the top seven chronic diseases in the U.S. Hence, epidemics of diabetes and heart disease are of major concerns for public health. CDC has identified tobacco use, poor nutrition, lack of physical activities, and excessive alcohol use are the key lifestyle risks for chronic disease. This research examines the associations between obesity, diabetes and heart disease and the underlying social economic factors.

This research specifically studies the disease rates in obesity, diabetes and heart disease in the state of Mississippi in 2005 - 2017. The reason to choose the state of Mississippi is because, in 2017, Mississippi ranked the 2nd highest in the U.S. for adult diabetes rate and the highest rate for youth between the ages of 10-17. Cardiovascular disease, including heart disease and stroke, is the leading cause of death in Mississippi, accounting for over a third of all deaths in the state. Mississippi's CVD mortality rate remains the highest in the nation. In 1990, Mississippi's adult obesity rate was 15.0%; increased to 23.7% in 2000 and grew to 37.3% in 2017 (The State of Obesity in Mississippi). Obesity in adults and children is a leading health concern for Mississippi. Obesity contributes to the major chronic disease killers in the state: heart disease, diabetes and certain cancers.

Obesity is one of the most important modifiable risk factors for the prevention of type 2 diabetes. Excess weight has been shown to be associated with an increased prevalence of type II diabetes, gastroesophageal reflux, hypertension, dyslipidemia, and certain cancers and both obesity and diabetes are associated with an increased risk for mortality, particularly from cardiovascular disease (Nguyen et al. 2011, 21:351-355).

Diabetes is treatable, but even when glucose levels are under control, it greatly increases the risk of heart disease and stroke. That is because people with diabetes, particularly type 2 diabetes, often have the following conditions that contribute to their risk for developing cardiovascular disease (Colhoun et al. 2002, 51:1949-1956): high blood pressure (hypertension), abnormal cholesterol and high triglycerides, obesity and lack of physical activity (Yusuf et al. 2005, 366:1640-1649).

The socioeconomic factors like educational status, income status, ethnic background, employment status affect the health of an individual. Higher disease rates are found in lower income levels and the least educated groups, particularly among women and certain ethnic groups. Studies have found that healthier food is generally more expensive and less readily available in poorer communities (Cummins et al. 2007, 65:1825-1838; Powell et al. 2007, 33:S301-S307). A higher level of risk is received by low socio economic status people and is prone to more chronic diseases. For example acute and chronic stress activate the hypo thalamo pituitary adrenal axis, which triggers the cascade of neuro endocrine alterations that play a vital role in depression, fat metabolism and insulin resistance (Pickering 1999, 896:262-277; Engert et al. 2002, 51:1629-1634).

The relation between obesity and coronary heart disease was viewed as indirect. Although most of the comorbidities relating obesity to coronary artery disease increase as BMI increases, they also relate to body fat distribution. Long-term longitudinal studies, however, indicate that obesity not only relates to but even independently predicts coronary atherosclerosis. This relation appears to exist for both men and women with minimal increases in BMI (Rabkin, Mathewson, and Hsu 1977, 39:452-458; Anjana et al. 2011, 54:3022-3027).

The goal of the study is to find the relation between obesity, heart disease and diabetes. It further aims to show that socio economic factors influence these disease rates. The study will not only help the State of Mississippi to carve out policy and actions to prevent and reduce obesity, diabetes and heart disease, but also help to identify socio economic factors that can be applied to prevent heart disease and diabetes. The

insights from the state of Mississippi would help other states to learn from the State of Mississippi and address the public health concerns related to obesity and disease rates.

## 2. RESEARCH METHODOLOGY

Diabetes, Heart Disease and Obesity data were obtained from the Centers for Disease Control and Prevention's (CDC) Behavioral Risk Factor Surveillance System (BRFSS) [see: [http://msdh.ms.gov/msdhsite/\\_static/31.0.110.html](http://msdh.ms.gov/msdhsite/_static/31.0.110.html)]. BRFSS collects data about U.S. residents from 51 states through telephone and landline surveys regarding their health-related risk behaviors and events, chronic health conditions, and use of preventive services. Each year, prevalence estimates are calculated for a sample size of about 5,000 interviews over a 12-month period. Data of individuals of different socio economic status (grouped by gender and race) were collected for the Mississippi from 2005 to 2017. All variables were grouped by gender and race.

Data transformation and statistical analysis were performed in R language using the R Studio interface. R Studio is used as a tool to subset data and perform statistical analyses like regression and forecasting. ETL procedures will be used to guide our data collection and analysis. Chronic health data will be extracted from the Behavioral Risk Factor Surveillance System (BRFSS) provided by Centers for Disease Control. Necessary transformations will be applied to select the desired data. Cleaned up data was loaded into R studio for further analysis.

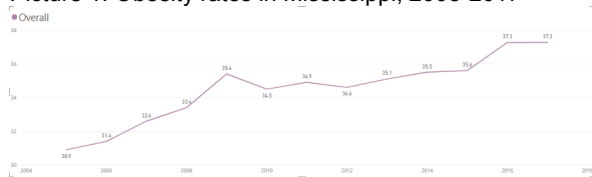
Data was filtered to the state of Mississippi (filtered under the field of "locationdesc"). The fields related to Chronic Health Indicators and Overweight and Obesity (BMI) were selected. Further, the indicators under the fields related to Arthritis, BMI Categories (Overweight and Obesity), Cardiovascular Disease, and Diabetes were used to filter the survey data. The study excluded responses that footnoted a blank response or an unavailability of prevalence estimation. Data is further divided into subsets for each of the following demographic categories of Gender, Household Income, Age, Race, and Education level.

## 3. RESULTS AND DISCUSSIONS

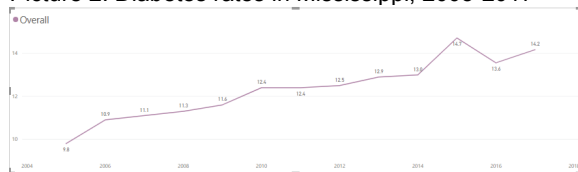
### 3.1 Diseases rates of obesity, diabetes, and heart disease in Mississippi, 2005 -2017

Obesity in Mississippi has increased from 30.9% in 2005 to 37.27% in 2017, with an average rate on 34.49% and a standard deviation of 1.96%. Diabetes rate has seen a slight increase from 5.2% in 2005 to 5.37% in 2017. Heart disease or myocardial infraction rate in Mississippi has been increasing from 9.8% in 2005 to 14.17% in 2017, with an average rate of 12.33% over the decade and a standard deviation of 1.38%. (see Pictures 1-3).

Picture 1. Obesity rates in Mississippi, 2005-2017



Picture 2. Diabetes rates in Mississippi, 2005-2017



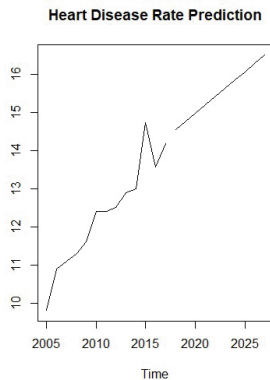
Picture 3. Heart disease rates in Mississippi, 2005-2017

In order to understand the relation between disease rates, a linear regression was performed. For the overall population, the results show that obesity is a strong predictor for heart disease in the state of Mississippi. A linear regression model predicting heart disease rates using obesity and diabetes rates as predictors shows that obesity is a significant predictor with a p-value of 8.14e-05 (see Table 1) and the an adjusted R<sup>2</sup> value of 0.7681.

On removing diabetes rate from the model, the p-value remains less than 0.0001 (p-value decreases further to 8.82e-05) and the model is with a slightly lower adjusted R<sup>2</sup> value of 0.7452. Using diabetes rate to predict heart disease is significant with a p-value less than 0.05 as well (p=0.0259) (see Table 1).

Based on the current trend, it is interesting to see how heart disease would grow in the next ten years. The Holt-Winters model was used to predict the next 10 years of heart disease rates, and the model predicts that heart disease will reach 16.5% in 2027.

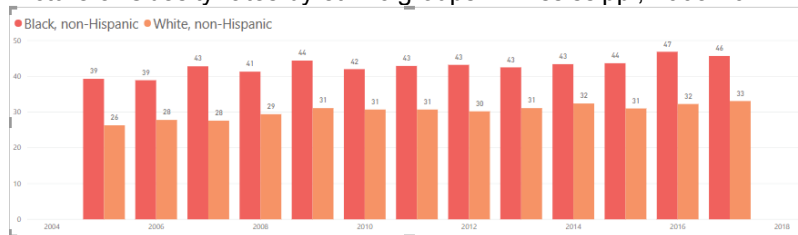
Picture 4. Heart Diseases Rates (2005-2017) and Rates Prediction in Mississippi (2017-2027) (with year on the x-axis, heart disease prevalence rate (in percentage) on the y-axis)



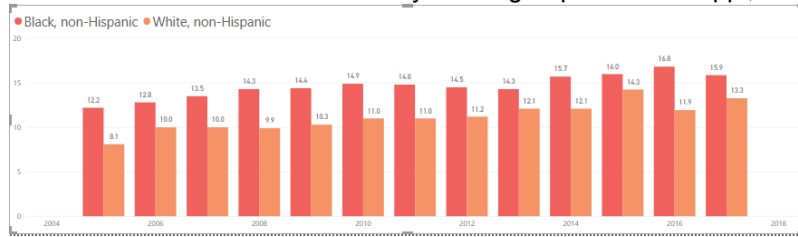
### 3.2 Diseases rates by ethnic groups in Mississippi, 2005 -2017

Among white, non-Hispanic population in Mississippi, obesity rate, which is lower than that of the Mississippi population, has increased from 26.30% in 2005 to 33.08% in 2017, with an average rate of 30.28% and a standard deviation of 2%; diabetes rate, which is higher than that of the Mississippi population, has increased from 8.1% in 2005 to 13.27% in 2017; and heart disease rate has increased from 4.9% in 2005 to 6.33% in 2017, with an average rate of 5.75% and a standard deviation of 0.61% (see Pictures 5-7). A linear regression model predicting heart disease rates using obesity and diabetes rates as predictors shows that diabetes is a significant predictor. The p-value of diabetes is 0.00444 and the adjusted R<sup>2</sup> value is 0.6827. On removing obesity rate from the model, the p-value remains highly significant (p-value decreases further to 0.000222) with a slightly higher adjusted R<sup>2</sup> value of 0.6999. Obesity rate predicting heart disease is significant (has a higher p-value of 0.024). Using obesity rate to predict diabetes is significant too with a p-value less than 0.05 and only slightly above 0.001 (p-value = 0.00104). Results show that diabetes is associated with heart disease in Caucasians; however, obesity is associated with diabetes.

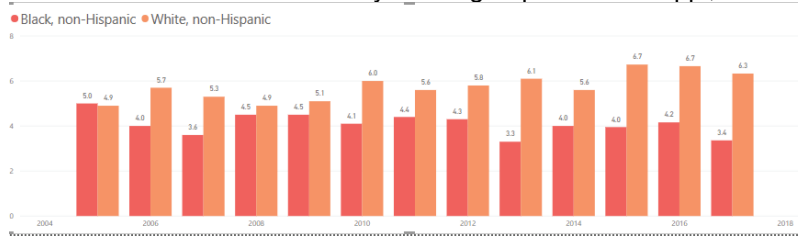
Picture 5. Obesity rates by ethnic groups in Mississippi, 2005-2017



Picture 6. Diabetes disease rates by ethnic groups in Mississippi, 2005-2017



Picture 7. Heart disease rates by ethnic groups in Mississippi, 2005-2017



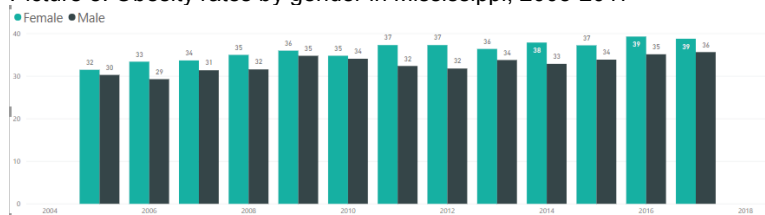
Among Black, non-Hispanic population, obesity, which is higher than that of the Mississippi population, has increased from 39.3% in 2005 to 45.69% in 2017, with an average rate of 42.84% and a standard deviation of 2.2%; Diabetes rate in this population, which is higher than that of the overall Mississippi population, has seen an increase from 12.2% in 2005 to 15.86% in 2017; however, heart disease rate has decreased from 5% in 2005 to 3.36% in 2017 (see Pictures 5-7). In African Americans, neither obesity nor diabetes shows a strong association with heart disease. However, obesity is strongly associated with diabetes with a highly significant p-value less than 0.001 ( $p=0.000136$ ). There may be other reasons for heart disease in this particular Black, non-Hispanic population.

### 3.3 Diseases rates by gender in Mississippi, 2005 -2017

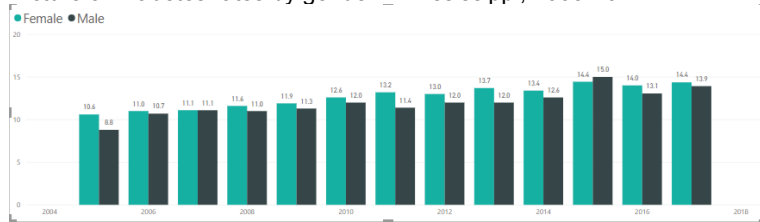
Obesity among males has increased from 30.3% in 2005 to 35.66% in 2017, with an average rate on 32.85% and a standard deviation of 1.92%. Diabetes rate, which is higher than that of the overall population, has seen an increase from 8.8% in 2005 to 13.93% in 2017. Heart disease rate has increased slightly from 6.4% in 2005 to 6.58% in 2017. See Picture 8-10. In the male population, neither obesity nor diabetes shows a strong association with heart disease. However, diabetes is significantly associated with obesity with a p-value less than 0.05 ( $p=0.00706$ ). There may be other reasons for heart disease in males.

Obesity rate among female, which is higher than that of the entire population in Mississippi, has increased from 31.5% in 2005 to 38.80% in 2017, with an average rate of 36.05% and a standard deviation of 2.2%. Diabetes rate, which is higher than that of the overall population, has seen an increase from 10.6% in 2005 to 14.37% in 2017. Heart disease rate has increased slightly from 4.1% in 2005 to 4.26% in 2017. (see Pictures 8-10). In females, obesity and diabetes show a moderate association with heart disease. Obesity rate predicting heart disease has a significant p-value less than 0.05 ( $p=0.0435$ ). Diabetes rate predicting heart disease has a significant p-value only slightly above 0.01 ( $p=0.0162$ ). However, diabetes is strongly associated with obesity with a highly significant p-value less than 0.001 ( $p=2.28e-05$ ).

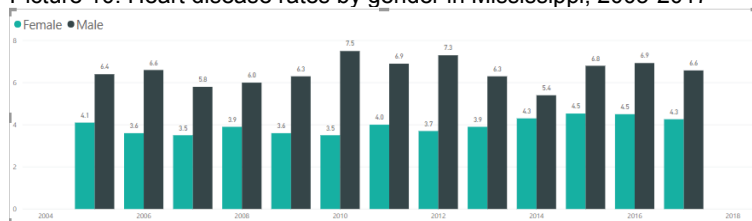
Picture 8. Obesity rates by gender in Mississippi, 2005-2017



Picture 9. Diabetes rates by gender in Mississippi, 2005-2017



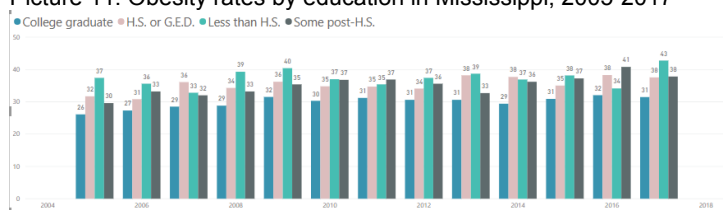
Picture 10. Heart disease rates by gender in Mississippi, 2005-2017



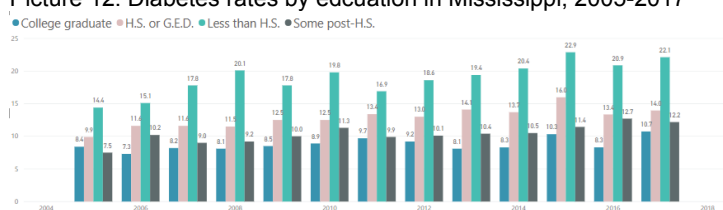
### 3.4 Diseases rates by education in Mississippi, 2005 -2017

Among College Graduates, obesity rate has increased from 26.1% in 2005 to 31.46% in 2017. Diabetes rate, which is higher than that of the overall population, has seen an increase from 8.4% in 2005 to 10.74% in 2017. Heart disease rate is lower than that the entire population; it has decreased from 3.2% in 2005 to 2.72% in 2017. Among people who have some post High School education, obesity has increased from 29.6% in 2005 to 37.82% in 2017. Diabetes rate, which is higher than that of the overall population, has seen an increase from 7.5% in 2005 to 12.18% in 2017. Heart disease rate is lower than that of the entire population; it has increased slightly from 3.7% in 2005 to 4.94% in 2017. Among those who have graduated with High School or General Educational Development (GED), obesity has increased from 31.7% in 2005 to 37.56% in 2017. Diabetes rate, which is higher than that of the overall population, has seen an increase from 9.9% in 2005 to 13.96% in 2017. Heart disease rate is lower than that of the entire population; it has increased from 4.9% in 2005 to 5.32% in 2017. For those who have less than High School education, obesity, which is higher than that of the overall population, has increased from 37.4% in 2005 to 42.77% in 2017. Diabetes rate, which is higher than that of the overall population, has seen an increase from 14.4% in 2005 to 22.12% in 2017. Heart disease rate is higher than that of the entire population; however, it has decreased slightly from 10.2% in 2005 to 9.28% in 2017. See Pictures 11-13.

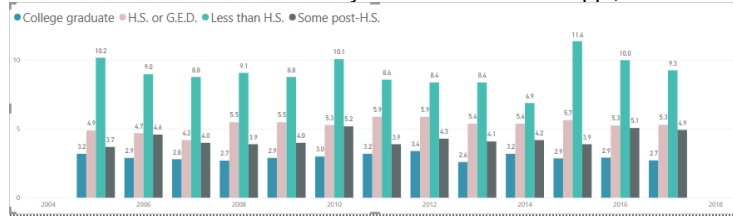
Picture 11. Obesity rates by education in Mississippi, 2005-2017



Picture 12. Diabetes rates by education in Mississippi, 2005-2017



Picture 13. Heart disease rates by education in Mississippi, 2005-2017

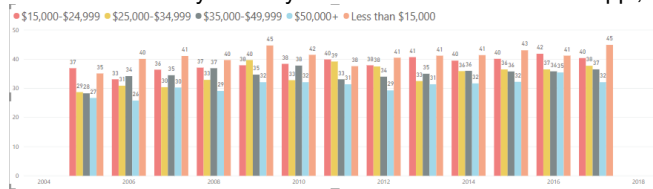


In college graduates, neither obesity nor diabetes shows a strong association with heart disease. However, diabetes is weakly associated with obesity with a p-value slightly higher than 0.05 ( $p=0.0554$ ). In the population with some post High School education, diabetes shows a moderate association with heart disease. Diabetes rate predicting heart disease has a significant p-value less than 0.05 ( $p=0.00284$ ). Obesity rate predicting heart disease also has a significant p-value less than 0.05 ( $p=0.026$ ). Diabetes is strongly associated with obesity with a highly significant p-value less than 0.001 ( $p=3.44e-05$ ) and an adjusted  $R^2$  of 0.7846. In people who have graduated High School or GED, diabetes shows a moderate association with heart disease. Diabetes rate predicting heart disease has a non-significant p-value slightly higher than 0.05 ( $p=0.0529$ ). However, diabetes is associated with obesity with a significant p-value less than 0.05 ( $p=0.038295$ ). In people with less than High School education, there were no strong associations between the disease rates.

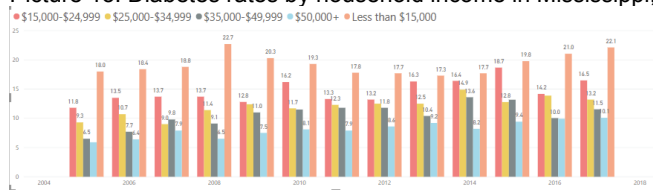
### 3.5 Diseases rates by household income in Mississippi, 2005 -2017

In households with income less than \$15,000, obesity, which is higher than that of the entire population, has increased from 35.1% in 2005 to 44.90% in 2017. Diabetes rate, which is higher than that of the overall population, has seen an increase from 18% in 2005 to 22.12% in 2017. Heart disease rate is higher than that of the entire population; it has decreased slightly from 11.3% in 2005 to 9.08% in 2017. In households with income from \$15,000 to \$24,999, obesity has increased from 36.9% in 2005 to 40.38% in 2017. Diabetes rate, which is similar to that of the overall population, has seen an increase from 11.8% in 2005 to 16.48% in 2017. Heart disease rate is similar to that of the entire population; it has decreased slightly from 6.7% in 2005 to 5.68% in 2017. In households with income from \$25,000 to \$34,999, obesity has increased from 28.7% in 2005 to 37.74% in 2017. Diabetes rate has seen an increase from 9.3% in 2005 to 13.20% in 2017. Heart disease rate has increased slightly from 5% in 2005 to 5.53% in 2017. In households with income from \$35,000 to \$49,999, obesity has increased from 28.3% in 2005 to 36.51% in 2017. Diabetes rate has seen an increase from 6.5% in 2005 to 11.54% in 2017. Heart disease rate has almost doubled from 3.4% in 2005 to 6.07% in 2017. In households with income over \$50,000, obesity, which is lower than that of the population, has increased from 26.7% in 2005 to 32.10% in 2017. Diabetes rate has almost doubled from 5.9% in 2005 to 10.09% in 2017. Heart disease rate is lower than that of the entire population; it has increased slightly from 2% in 2005 to 3.4% in 2017. See Pictures 14-16.

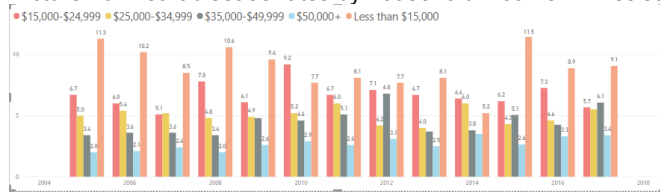
Picture 14. Obesity rates by household income in Mississippi, 2005-2017



Picture 15. Diabetes rates by household income in Mississippi, 2005-2017



Picture 16. Heart disease rates by household income in Mississippi, 2005-2017



In households with income less than \$15,000, using obesity and diabetes as predictors, diabetes shows a weak association with heart disease with a non-significant p-value of 0.0775. Factors taken individually are not significant. In households with income from \$15,000 to \$24,999, neither obesity nor diabetes shows a strong association with heart disease. However, diabetes is weakly associated with obesity with a non-significant p-value of 0.0758. In households with income from \$25,000 to \$34,999, neither obesity nor diabetes shows a strong association with heart disease. However, diabetes is significant associated with obesity with a significant p-value less than 0.01 ( $p=0.00508$ ). In households with income from \$35,000 to \$49,999, diabetes shows a mild association with heart disease with a p-value slightly higher than 0.05 ( $p=0.0505$ ). Diabetes is significantly associated with obesity with a p-value less than 0.05 ( $p=0.0429$ ). In households with income over \$50,000, obesity shows a significant association with heart disease with a significant p-value less than 0.05 ( $p=0.00848$ ). Diabetes is significantly associated with heart disease with a p-value less than 0.05 ( $p=0.00235$ ). Diabetes has highly significant association with obesity with a p-value slightly higher than 0.001 ( $p=0.00103$ ).

#### 4. CONCLUSION

This study has shown that there is a lot of inter relationship among the different diseases. For instance, there exists a relationship between diabetes, obesity, heart disease, which tells that occurrence of any one of the diseases could have an association with the onset of others) (e.g., obesity may have an association to diabetes, diabetes may have an association to heart disease). The analyzed data also demonstrate that socio economic factors play a vital role in the onset of diseases and hence the health of an individual. For example, people who get low salaries are at high risk of obesity, diabetes and/or heart disease as it is difficult for them to get healthy food or engage in fitness activities. Obesity, diabetes and heart disease could be controlled by individuals (e.g., improvement in social-economic status) and mediated by policies made by the State Department of Health and other related policy makers (e.g., community programs to enhance education/career development and to improve access to healthy food and fitness activities). As data have shown some decrease in certain disease rates in targeted groups, the effects of individual controls and public assistance programs may make a difference and cannot be ignored.

From the data analysis, there is clear understanding how socio economic factors would result in incidence of many serious diseases. A better understanding about these issues may lead to suppression of prevalent diseases and hence the improvement in public health. The study can be extended to other states in the United States facing the epidemic of increasing obesity. The effect of obesity on diseases other than diabetes and heart disease can also be studied to improve overall health of the population.



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