The Correlation Between Sugar Sweetened Beverages and Cardiovascular Diseases

Word Count: 4017

Abstract

Cardiovascular diseases (CVDs) are the number one cause of death in the United States and the rest of the world. One potential contributor to this is sugar, specifically sugar sweetened beverages (SSB) with their high sugar content. This paper researches the extent of the correlation between sugar sweetened beverages consumption and cardiovascular disease within specific ethnic groups in the US: Asian, Hispanic, African American, and Caucasian. Research was conducted through systematic literature review and data collection papers from those papers. Literature was collected through CSUCI and online research databases. A correlation between SSB and CVD was found that is more significant than saturated fats. Additionally, the correlation between SSB and CVD affects certain ethnic groups more than others.

Keywords: sugar sweetened beverages, sugar, national health and nutrition examination survey, cardiovascular disease, ethnic groups,

Introduction

Cardiovascular Diseases

800,000 people die from cardiovascular disease (CVD) every year, making it the number one cause of death in the world (Food and Drug Administration, 2017). CVD, as defined by the American Heart Association (AHA), involves problems associated with the buildup of plaque within blood vessels. This plaque prevents blood from flowing to certain areas of the heart; these heart cells then die due to the lack of oxygen transported to them and can lead to additional health problems such as stroke and heart attacks. (American Heart Association, 2018). There are a number of things that causes this plaque build up. This paper will focus on a single factor: an unhealthy diet.

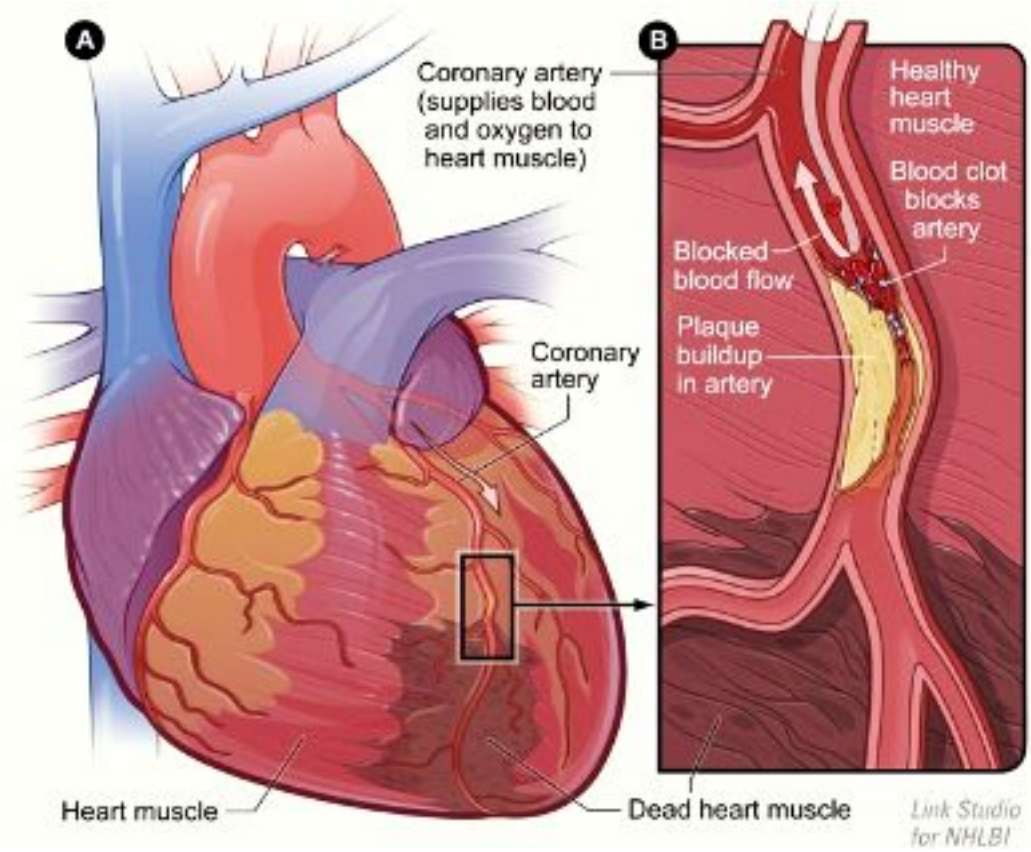

Figure 1. A) Human heart colored coded with deoxygenated (blue) and oxygenated (red) blood. Coronary

arteries labeled. B) When plaque increases within an artery, blood cannot flow as easily through vessel and is not able to oxygenate surrounding tissues. As a result, the muscle begins to die.
Credit to National Institutes of Health 2009

Factors that Cause Cardiovascular Disease

CVD is caused by multiple factors: smoking, a lack of physical activity, obesity, and more. Smoking primarily causes CVD by damaging and constricting arteries, resulting in the build up of fatty material (Parmet et al. 2003). Smoking is one of the largest contributors to the development of CVD and one of the most preventable. Currently, smoking is less of a significant contributor to CVD because a recent decrease of smokers. The CDC projected a 10% decrease in the past decades (Center for Disease Control, 2015).

A lack of exercise is another known factor of chronic diseases such as CVD. Booth et al. (2012) concluded in a multi-study analysis that exercise acts as a preventative measure from the development of chronic disease and the lack of sufficient exercise causes the body to maladapt rapidly. Exercise is another major factor of CVD in both development and prevention of CVD.

Obesity is another factor that influences CVD risk. People with obesity have higher chances of CVD. However, researchers from the AHA found that obesity is not an effective way to predict risks as this relationship is more of an association and not a direct factor (Aune et al., 2016). High BMI is caused by the same factors that caused CVD and does not have a direct correlation. All of these factors are pretty well known by the public. This paper will focus on the dietary causes of CVD, a controversial topic.

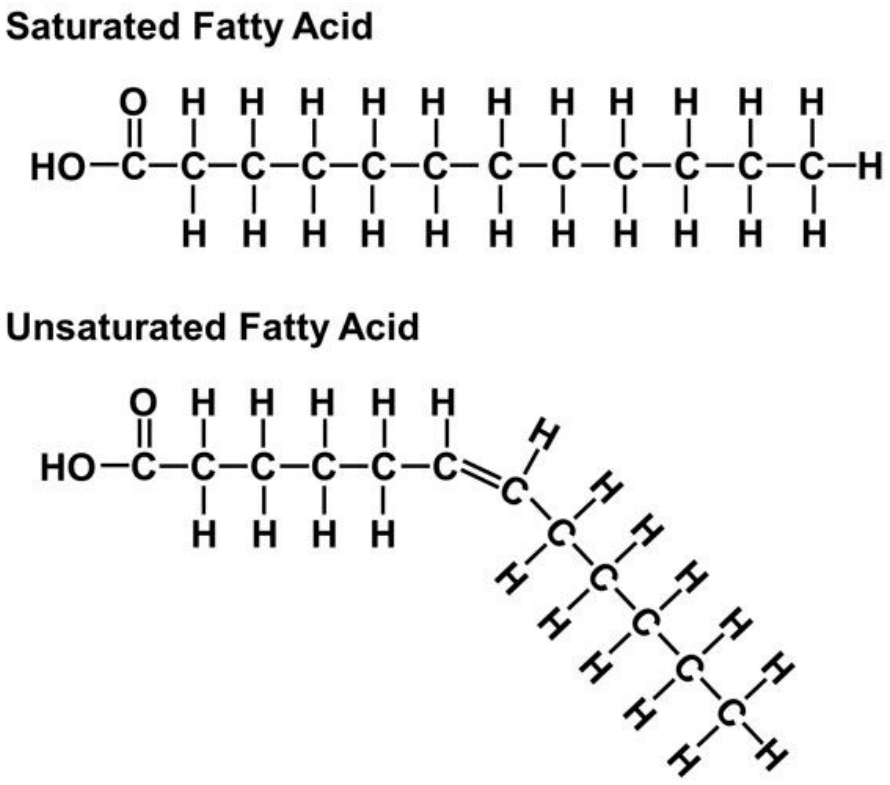

Figure 3: Chemical composition of a saturated and unsaturated fatty acid. The unsaturated fatty acid shows a double bond between carbon atoms while the saturated fatty acid does not.
Credit to https://dlc.dcccd.edu/biology1-3/lipids

Saturated Fat Consumption

Fats, specifically saturated fats, are commonly known to the public as the main dietary cause of CVD. As a result of this WHO recommends a 5-6% intake of total kcal per day (WHO, 2018). Shown in Figure 3, saturated fats are fat molecules that lack a double bond between carbon atoms. Fats are mostly found in animal products, such as animal fats. According to the AHA, saturated fats consumption causes an increase in cholesterol which can increase risk of heart disease. However, in a twenty one study meta analysis on the association of saturated fat with CVD, Siri- Tarion et al. (2010) found no evidence proving that saturated fats have a

significant effect on CVD. Nettleton et al. (2017) further supports Siri- Tarion et al. (2010) by using randomized control trials where they also found no significant correlation on saturated fat and CVD.

Sugar Consumption

Excessive sugar intake is already known to cause a multitude of problems such as obesity, type 2 diabetes, kidney diseases, tooth decay and cavities, and gout (AHA, 2018). Due to these health reasons, the World Health Organization has recently decreased total percent calorie intake of sugar from 10% to 5% (WHO, 2018). However, a controversial topic is the extent of sugar consumption effects on the heart. Recent research papers and media coverage reveal the sugar industry has been hiding the complete effects of sugar. Aubrey et al. (2017) investigated how the Sugar Association downplayed the true effects of sugar consumption in the 1960s by funding research that downplayed sugars effects on the heart. The sugar industry influenced the public's knowledge on the correlation between sugar and CVD, instead, suggesting saturated fatty acids as the key dietary factor of CVD (Kearns et al., 2016). Thus, while saturated fat consumption exponentially decreased, sugar consumption steadily increased. The sugar industry's influence has resulted in significant changes in the American diet, public misinformation, and a lack of research on sugar as a contributor to CVD.

Figure 4: Popular SSB, Monster, Vitamin Water, Mountain Dew, Snapple, Gatorade, and Nantucket Nectars Cranberry. It depicts its sugar contents showing extremely high sugar contents for each drink. Credit to: https://sites.psu.edu/siowfa15/2015/12/02/sugar-sweetened-drinks-cause-heart-disease/

Sugar Sweetened Beverages

Sugar is found in sugar sweetened beverages (SSB), most commonly in the form of high fructose corn syrup. SSBs are any beverage with sugar added as a sweetener. This includes sodas, lemonade, juice, energy drinks, etc. It accounts for 37.1% of total sugar consumption, followed by 13.7% from grain based desserts (Bunag RD et al., 2013). On average, one can of soda contains 39 grams of sugar (USDA, 2018). This surpasses the American Heart Association recommends a daily intake of 25-36 grams of sugar (AHA, 2018). Figure 4 shows these high sugar contents; the greatest sugar content drink, Mountain Dew, accounts for 64% of the daily recommended sugar consumption.Vitamin Water, accounts for 26% of the daily consumption. All SSB shown in the figure above easily surpasses the daily recommendation of sugar intake, not accounting for sugars consumed in other foods. Because of their high sugar content, researchers suggest that excessive sugar consumption is caused by SSBs (Vaanti et al. 2010).

This is especially concerning due to their high consumption rates in the United States. In California, up to 20% of its population drinks one to two cans of soda every day (Vartanian et al. 2007). However, despite the excess quantities of sugar in these drinks, there is still a high consumption rate of these drinks. The combination of high sugar content and consumption is suggested by researchers to cause an increase risk in CVD. (Huang et al., 2014).

Alternatives to SSB's, such as sugar free sodas, use alternative sweeteners. Researchers are concerned that artificial sugars result in negative health effects including cancer, diabetes, stroke, or even increase the chance of CVDs (Yang et al., 2014). However, the dispute over alternate sugar is a controversial debate in itself. Despite these potential health effects, sales of sugarless drinks is significantly fewer than regular SSB. For instance, the brand value of Coca-Cola is $66,489 million compared to Diet Coke's brand value of $11,653 million (Statista 2018). Despite one being healthier, there is a significant difference in value between these two brands, demonstrating a lesser appeal to healthier alternatives. Ultimately, consumers greatly prefer regular SSB to diet drinks.

Sugar Consumption on the Heart

There is controversy on the extent of sugar effects on the heart. This is caused by the sugar industries influence in the 60's and inconsistencies in research papers. For example, Eshalk et al, (2012), performed a prospective study on a 39,786 Japanese men and women. During the 18 year follow up, they found that soft drink intake was not associated with risk of ischemic heart disease or hemorrhagic stroke. There are studies like these that find no correlation between SSB and CVD; however, plenty of papers that suggest the opposite. For example, studies by

DiNicolantonio & OKeefe (2017), Yang et al., (2014), and more have found a correlation between SSB and CVD, although the extent of the correlation is disputed among each paper. This inconsistencies in multiple papers have resulted in a confusion on how much sugar has an effect on the heart.

Demographics Being Affected

Different demographics consume varying levels of SSB and have different CVD risk levels (Kannel & Vokonas., 1992). For example, researchers found children experiencing unhealthy weight gain leads to CVD (Scharf et al., 2016). Additionally, other factors such as socio economic status, region, and gender have varying influences. This paper will use those differences to find the extent of the correlation between SSB and CVD.

Purpose

The purpose of this study is to understand the relationship between SSB intake and CVD rates. In addition, current literature suggests this relationship is more significant than other dietary factors affecting CVD rates. To this date, there is no clear research determining the extent of this relationship. This study will attempt to address that issue by comparing SSB to saturated fats consumption and comparing those trends to CVD rates, making this study unique from others. This study will compare the association of SSB and saturated fats to CVD rates, to determine which food has more of an effect.

The sugar industry's influence on research have contributed to a wide scale unawareness and lack of research on this topic. Creating awareness may possibly decrease the amount of sugar

sweetened beverages consumed. As a result, it would reduce the negative health effects, decrease obesity rates, promote healthier diets by providing a healthier alternative to SSBs, and stimulate more research on this topic. Greater knowledge on this topic can allow people to make more educated decisions on their diet. Additionally, solutions such as taxes can be used to decrease SSB consumption (Shrapnel et al., 2015) or alternative sugar, such as aspartame or miraculin. (Rodrigues et al., 2016) can be implemented. No matter what means used, researchers found a decrease in SSB consumption results in a decrease of cardiovascular related deaths (Mekonnen et al., 2013). By identifying what ethnic groups are being affected, these groups can be targeted to decrease the amount of SSB consumption and potentially CVD rates.

Research Question

Is there a significant correlation between sugar consumption and cardiovascular disease?

Hypothesis/ Null Hypothesis

The alternate hypothesis:There is a significant correlation between cardiovascular disease and excess sugar consumption.

The null hypothesis: There is no significant correlation between cardiovascular disease and excess sugar consumption

Methods

Data Sources

Ebscohost, Google Scholar, Public Library of Science, PUBMED-NCBI, and California State University Channel Islands were the databases used for both systematic literature review and statistical analysis for finding a correlation between SSB and CVD. Keywords searched in these sources where “sugar sweetened beverages”, “cardiovascular disease”, “sugar consumption”, “National Health and Nutrition Examination Survey”, “ethnicity” and “myocardial infarction”. Additional sources where found through references of already gathered papers.

National Health and Nutrition Examination Survey

The National Health and Nutrition Examination Survey (NHANES) is a national study based in the United States, that surveys, interviews, and examines adults and children throughout the world (CDC, 2018). NHANES finds the health and nutritional status, of US civilians. It is a credible program that is run by the National Center of Health Statistics, a part of the Center for Disease Control. It began in the 1960’s and was conducted periodically until the 1999 where it was then conducted annually. It takes samples across the country, making it have diverse subject base.

Data collection in this paper relied on the use of NHANES, currently, there is not enough research or data on sugars mechanical effects on the heart, such as its effect on blood pressure or

triglyceride levels. Use of NHANES is the most effective method because it is a major study that uses a nationally represented subject data, representing all demographics, and it has information on their nutrition. Data in this is paper is based off research who used this survey instead of directly obtaining it from NHANES. Directly obtaining it from NHANES would of taken an immense amount of time. Data is collected from NHANES studies from the years 1988-2014. This results in a culmination of 23 years worth of data, (not 26 years due to NHANES being inactive between 1995 -1998). Data is based on hispanic, non hispanic whites, non hispanic blacks, and asian/ pacific islander consumption rate of SSB.

Ethnicity

Each demographic has different consumption levels of SSB and heart disease. Because of this, data collection is based around ethnicity. Data is sorted as a parametric function. The x value being energy intake from SSBs (kcal/d), the y value being deaths caused by CVD per 100, 000, and the t value, or third parameter being ethnicity. Focusing on their ethnic averages rather other factors such as age and gender, eliminated discrepancies that can potentially happen with different body types. For example, gender and age matters because of slightly different body types. Younger ages are able to metabolize sugar better than older ages, making them less susceptible to CVD. Women and children are also more resistant to CVD as they have less overall CVD cases, albeit not invulnerable to CVD (Maas et al., 2013; Daniels et al., 2011). These factors can caused more discrepancies in the data. Additionally, by combining averages of each gender in ethnicity helps represented the population as a whole. Another factor that can

influence data, region where they live, this is eliminated because data must use nationally represented samples, instead of samples in certain regions. However, other factors that are not completely accounted for in data collection is socioeconomic status and level of education.

Focusing on ethnicities finds which ethnicities are at the most risk and provides the least discriminant value to find trends. Additionally, sorting data by ethnicity allows preventive measures to be based off this data. Narrowing my scope to different ethnicities allows me to most effectively find trends and risk levels, making my paper unique.

In order to find the extent of the correlation, this paper will compare saturated fat and sugar sweetened beverage consumption rates by ethnicity. Saturated fats will act as a control to compare to sugar sweetened beverages. Comparing the two determined both factor's significance..

Selection Criteria

Studies where selected based on the following criteria:

1. Studies must be scholarly (peer reviewed) journals
2. Studies must use data from a nationally represented sample (NHANES, NHIS)
3. Studies must include participants aged ≥20 y
4. Studies must sort data by ethnicity

Results

Data Set	Total n value	Asians or Pacific Islanders	Non-Hispanic Whites	Hispanics	Non Hispanic Blacks	p value	aged ≥20 y	Study Analyzed
Energy intake from SSBs (kcal/d)								
NHANES III; 1988–1994	15979	/	160 ± 6	153 ± 7	175 ± 4	<0.001	yes	Bleich *et al*
NHANES 1999–2004	13431	/	205 ± 6	192 ± 8	234 ± 8	<0.001	yes	Bleich et al
NHANES 2005-2010	10628	/	138.5±11	170.4±13	183.4±14	<0.001	yes	Kit et al
NHANES 2011-2014	29133	70.6±7	132.1±7	178.5±7	196.3±9	<0.001	yes	Rosinger et al
Averages	Total Averages	70.6±7	158.9±7	173.5±9	197.2±9	<0.001		

Table 1: Data collection on SSB consumption by ethnicity. Displays the data set, n value, ethnicity consumption levels, p value, ages, and studies used. The bottom row displays the averages of all the data.

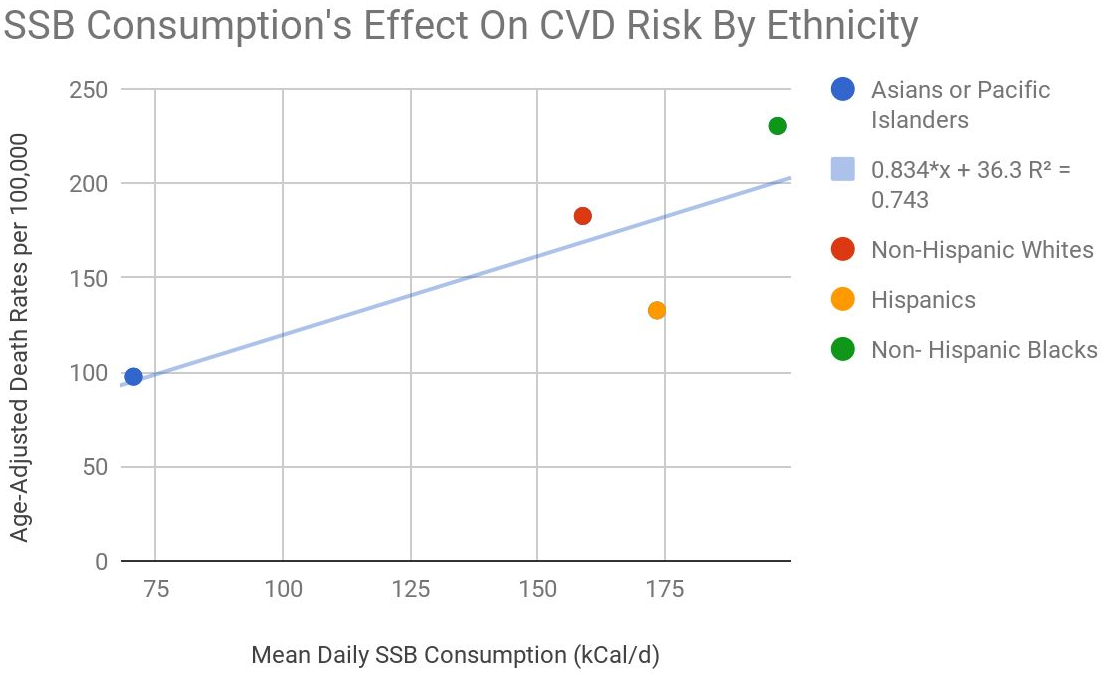

Figure 4. This depicts an increase of SSB in kCal/d results in an increase of CVD death rates sorted by ethnicity

Figure 4 displays the Mean Daily SSB Consumption in kcal relationship with CVD death rates, sorted by ethnicity. The trend line has a slope of 0.828x+24.7 and a R squared value of 0.707. The outlier from the trend line is the Hispanic ethnic group. They have an increased amount of SSB consumption, Ethnicities used are Asian or Pacific Islander, Non- Hispanic Whites, Hispanics, and Non- Hispanic Blacks.

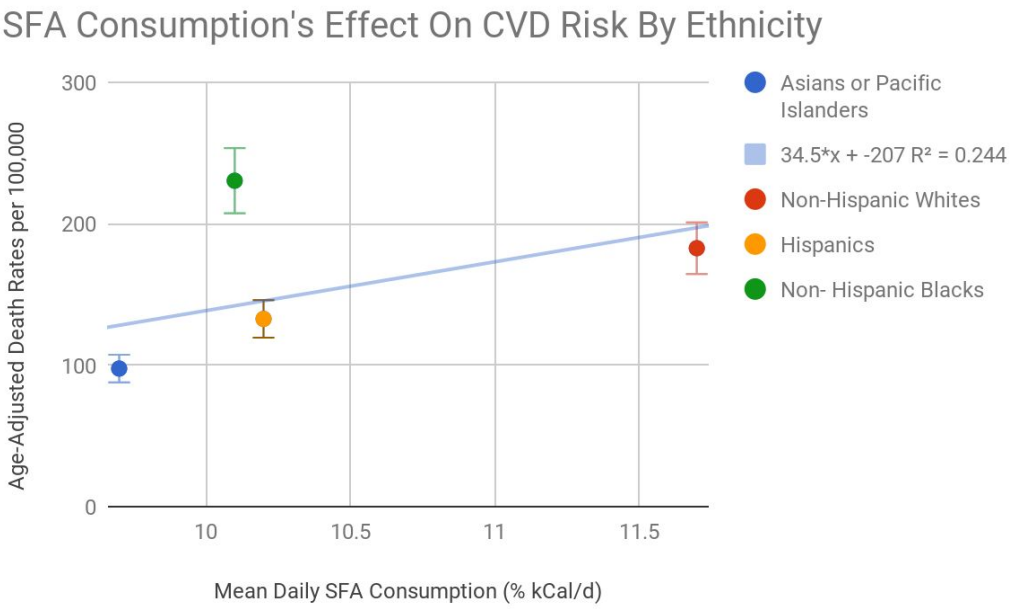

Figure 5. An increase of saturated fat acids (SFA) consumption results in a increase of death rates.

Figure 5 shows ethnicities that consume higher levels of saturated fats acids have higher CVD death rates per 100,000. The best fit line equation is 34.5x - 207. The R squared value is 0.244. All ethnicities consume similar amounts of saturated fats, within the range of 9 and 11%. The highest difference was between Asians or Pacific Islanders and Non- Hispanic Whites, with a difference of <2% consumption rates. The outlier here is Non- Hispanic Blacks, where they have an increased amount of CVD related deaths, despite a relatively lower consumption rate.

Limitations

Limitations of my data stemmed from a lack of data on individual effects on the heart. There are very few studies that test the individual factors on the heart, due to this data collection instead had to rely on trends in the population. Finding population trends does not isolate the

factors that cause CVD used in the study. These factors include smoking, obesity, physical activity, or emotional levels can interfere with the data. SSB consumption cannot be isolated from other factors from surveyees that can cause CVD. This can further influence my results. However, by using such a large sample sizes, this influence is minimized. The genetic factors in ethnic groups presents another limitation. One flaw in my data is the relative lack of data for Asian Americans and their sugar consumption. Additionally, there is relative lack of data on Asian Americans. While other ethnicities had data from NHANES that spanned over over 23 years, Asian Americans only had a total of 3 years worth of data.

Discussion

Figure 4 shows the Age-Adjusted Death Rates per 100,000 to daily SSB consumption consumption by ethnicity/ race. Using this graph, risk levels for CVD can be predicted. The results suggest an increase of SSB consumption, which varies by ethnicity, results in higher CVD risks and rates. Consumption of SSB based on % kcal/d is the least for the Asian ethnic group and Asian CVD cases are the lowest. This trend is consistent with all ethnic groups, except for Hispanics, in which they have the second lowest CVD rates, but the second highest SSB consumption rates. Comparing the two best fit lines in Figures 4 and 5, shows a significant difference between the two. SSB has a 0.834x + 36.3 while SFA has a value of 34.5x -207. Consuming more SSB increases your risk compared to SFA. This proves the correlation between the SSB and CVD.This correlation is shown to be more significant than SFA. This supports my alternative hypothesis. Using this, risk factors can be determined in different populations by identifying SSB and sugar consumption. However, SSB consumption is not the sole contributor,

while it is a major one, high SSB consumption usually indicates other poor dietary choices, such as lack of exercising, resulting in such a high risk. Through these calculations we can predict which groups are at a higher risk. In this case, African Americans are at a higher risk as their SSB consumption is the highest. This can extend past ethnic groups and into different demographics such as age, gender, place of residence, and more which allows to take preemptive measures.

From the data collected, SFA seems to have little to no effect on SSB consumption. The best fit line in Figure 5 shows very little increase compared to saturated fats. Ethnicities consume very similar amounts of SFA, all within the range of 9 and 12 % kcal/d. Additionally, a low R squared value of 0.224 shows how inconsistent the data is, ultimately, suggesting that there is no correlation between SFA and CVD.

This lack of correlation found in the data is due to different types of cholesterol found in the blood. According to Hao et al. (2014), saturated fats increase the large low-density lipoprotein (LDL) cholesterol. Large LDL cholesterol is found to have no effect on the development of CVD and is actually found to help prevent CVD. However, small LDL cholesterol, which is found in trans fats, does contribute to the plaque build up in CVD. Due to difference between the two, SFA have little to no correlation and provides an explanation for my results. Some research has even suggested that SFA decreases the risk of CVD (Malhotra et al., 2017).

This relationship explains the results of Eshalk et al. (2012), where they found no correlation between CVD and SSB. Their study exclusively used an Asian demographic,

specifically the Japanese population, which is the least affected by CVD. Their focus on the Japanese population hindered their results, making them find no correlation.

In Figure 4, a discrepancy can be seen in the hispanic ethnic group. The hispanic ethnic group has a higher SSB consumption rate, yet lower instances of CVD compared to non hispanic whites. Further research on this topic reveals the hispanic paradox. According to Mendina-Inojosa et al. (2014), the Hispanic paradox is a phenomenon found in multiple cohorts, where hispanics are found to live longer than non hispanic whites despite higher instances of CVD. Figure 4 shows CVD related deaths and not total CVD cases, but it does explain the inconsistency in the results.

Eshalk et al.'s (2012) study and the hispanic paradox suggest genetic factors may have an influence on this correlation. Genetic factors is another limitation that is found in my research.

Currently, there is limited knowledge on the mechanics of sugar on the heart that would explain my results. However, researchers believe this correlation is caused by a multitude of pathways (Yang et al., 2014). Fried et al. (2003) researches how excessive sugar intake may be related to the development of hypertension, abnormally high blood pressure. In their research they concluded that excessive sugar intake, independent from weight gain, can lead to hypertension,.This high pressure can lead to health complications such as CVD. Researchers from the AHA further supports this theory. Using a sample size of 2696 people, they recorded BP before and after periods of sugar intake, concluding a direct association between sugar intake and blood pressure (AHA, 2018). Increased blood pressure is a known factor of CVD and considered one of the leading causes of CVD (Makridakis et al., 2014). Welsh et al. (2010)

researched sugar's effects on triglyceride levels. Triglycerides are lipids in the blood stream that contributes to the plaque buildup. Triglyceride enters the bloodstream when insulin converts excess calories, such as sugar, into triglycerides. Sugar is found in excess in SSB, so that excess is transformed in elevated levels of triglycerides, contributing to plaque build up, and therefore CVD. Despite this, there is still not enough research on the mechanics to have a general conclusion.

In Table 1, every ethnicity follows the same trend over time. It shows an increase from 1988 and 2004 and a slight decrease following it. This suggests that SSB consumption over time is going down, albeit not significantly.

Conclusion

Currently, the public opinion on SSB's effect on the heart is skewed. The belief that high cholesterol in a diet is one of the main causes has manipulated the world's diets away from another major source of CVD, SSB. As suggested from the data, a correlation is evident between sugar consumption by SSB and cardiovascular disease that is more significant than saturated fats effect on the heart. This varies from the Hispanic, African American, and Caucasian ethnic groups. Ultimately, the alternate hypothesis of a correlation between CVD and sugar consumption is confirmed. From the statistical analysis, the ethnic group that seems to be the most affected by this correlation is the Hispanic ethnic group, followed by African Americans, and Caucasian ethnic group. With this knowledge, efforts can be made to target these groups and decrease the risk of CVD.

Further Work

This research's data has limitations. Further work should be conducted on doing research to find more data on this correlation. For example, seeing SSB consumption effect on blood pressure, because blood pressure is a major contributing factor to SSB, or making SSB consumption an isolated variable, eliminating all other variables in diet, lack of exercise, BMI, and other factors. This way there will be a better understanding of its relationship. Further work would be researching the causation.

Certain demographics are being affected more by this epidemic more than others. Socioeconomic status, One theory is that due to the ease of accessibility in certain neighborhoods results in higher sugar consumption in those areas as opposed to other neighborhoods with harder accessibility to these substances. Research on how sugar affects the cardiovascular system in such a negative way also must be conclusive, while theories exist, there is no confirmed way of how the mechanics work.

Additional research should be conducted on preventive measures, or how to stop increased SSB risks. One proposed way is to increase taxes in places where SSB consumption is high, as an effort decrease consumption. Another method is through targeted education in high consumption areas, teaching better dietary choices and a healthier lifestyle. Additionally, research should be conducted on sugar's effect on liver cancer, as this was another subject that the sugar industry covered up.

Other trends found during data collection where younger ages tended to consume more SSB but overall have less CVD rates. Additionally, the lower the socio economic status and region the higher the SSB consumption and CVD risk. Women also tended to consume less SSB

and have lower risk of CVD compared to men. Further work should be done on these relationships.

Further research should be done on the hispanic paradox. This paradox is not well researched or known. Going in depth into this topic can result in a better understanding of the factors causing CVD and can potentially discover a way to decrease CVD risk. Additionally, further research should be done on SFA's true effects on the heart. Research on this topic is inconsistent. Results from research ranges from SFA has a significant correlation, to no correlation, or even a decrease effect on heart disease. Ultimately, the correlation between SSB and CVD brings many further research to be conducted on this topic.

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