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Do Global Diets Affect the Rate of Type 2 Diabetes?

Demetria Meyer

Honors College Thesis

Western Michigan University
Abstract

The purpose of this study is to determine whether different global diets correlate with the increase in type 2 diabetes rates. Type 2 diabetes is the main diabetes type being looked at due to it being the one that can be maintained primarily by glycemic control, which is controlled by a good diet. Five different countries from different regions will be examined: Brazil, China, Micronesia, Nigeria, and the United States. The diets of these countries will be broken down into smaller pieces, like calories consumed each day and the percentage of macronutrients that make up the calories. Eleven food groups are also looked at by how many grams each country consumes per day. Other factors within the countries will be discussed, such as access to health care and genetics, to better determine if the diet is what is affecting the rate of diabetes. Then, each of these components will be analyzed to determine if there is a correlation between global diets and how they affect Type 2 diabetes (T2DM) rates.
Introduction

Diabetes is a major disease that affects approximately 8.5 percent of the global population (World Health Organization, 2017). About 90-95 percent of diabetes cases are Type 2 (T2DM), which means a person’s body cannot correctly utilize the insulin that is produced, so glucose builds up in the blood leading to high levels of blood glucose (sometimes referred to as “sugar”) that can cause a variety of health problems. Two main causes of Type 2 diabetes are obesity and diet. Being obese can worsen diabetes depending on where the fat is positioned on the body. For example, someone with most of their body fat around their midsection is likely to have higher insulin resistance than someone who has most of their body fat in other areas. This is due to fat cells releasing inflammatory chemicals that can decrease the sensitivity of the body to insulin, leading to insulin resistance (Diabetes.co.uk, 2017). In turn, diet can fuel obesity if a person consumes energy-dense foods and does not exercise enough to work off the excess calories consumed (Chatterjee, Khunti, & Davies, 2017). This leads to the body receiving more calories than it needs, which can cause it to store the excess as fat, thereby leading to decreased insulin sensitivity. Or the body will try to produce more insulin to keep up with the increase of carbohydrates that need to be broken down, which can lead to stress on the pancreas to produce more beta cells or on the body to try to utilize insulin (Chatterjee, Khunti, & Davies, 2017). Consuming too many calories or foods containing glucose can lead to obesity that can lead a person to cardiovascular diseases (CVD), which can then lead to a person having complications with maintaining their diabetes (Chatterjee, Khunti, & Davies, 2017).

Glucose is a form of carbohydrate (CHO) and it is very important to maintain a healthy balance of CHOs in the diet of those with diabetes. CHO is a term that groups together sugar, starch, simple and complex carbs, and fiber. CHOs are necessary for the body to obtain energy,
along with proteins and fats, however, they do not produce as much energy as fats, but the body is able to use them the fastest, so CHOs are used as the primary energy source (Daries, 2012). When a person consumes a carbohydrate, it is broken down and enters the blood as glucose, so the more CHOs a person eats, the more glucose they are building up in their blood (Daries, 2012). This can lead to their body needing to work overtime in producing insulin to help control the amount of glucose in their blood by having cells take it up to be used as energy, or for the liver to store it as glycogen (a compact form of glucose) (Newsholme & Dimitriadis, 2001).

There are several types of CHOs, such as, simple, complex, refined, and unrefined. Simple CHOs are known as sugars, either 1 or 2 sugar molecules, and complex CHOs are known as starches, which are chains of sugars (Jenkins, Jenkins, Wolever, Thompson, & Rao, 1986). Refined carbohydrates are grains that have undergone some type of treatment, like white flour or sweeteners, whereas unrefined carbohydrates are foods that have not been altered in any way, like whole grain bread or raw vegetables, and unrefined carbohydrates are usually rich in fiber (Venhaus & Chantelau, 1988). Unrefined CHOs can help the body regulate blood glucose levels due to the dietary fiber they contain, so fiber in a diabetic’s diet would be beneficial (Daries, 2012). However, for refined carbohydrates, studies have shown that an increased consumption of them correlates with an increase in T2DM due to this type of CHO lacking many essential nutrients that unrefined CHOs have (Gross, Li, Ford, & Liu, 2004). Some foods that contain carbohydrates are “vegetables, fruits, cereals, grains, legume-type food, as well as sugary foods and drinks”, also some animal products, like milk, some cheeses, and yogurt (Daries, 2012). Carbohydrates are the most important nutrient to monitor when preparing foods to eat as a diabetic because they will break down into glucose in the body therefore requiring insulin to utilize it.
The metabolism of glucose is the primary source of energy for the body, however, it is also the main source of issues for those with diabetes due to insulin being required for the metabolic process. According to Bouche et. al. (2004), glucose is first transported into cells so that ATP may be generated. However, glucose cannot go through the lipid bilayer of the cell on its own, so it requires the use of two types of transporters known as facilitative glucose transporters (GLUTs) and sodium-glucose cotransporters (SGLTs). GLUTs function throughout the entire body whereas SGLTs primarily function at the intestine and kidneys due to the organs playing roles in sodium absorption. However, for the transporters to be activated they must first be bound to insulin, a hormone released from the pancreas (Wilcox, 2005). Once inside the cells glucose can then be phosphorylated into glucose 6-phosphate by using enzymes known as hexokinases (Bouche, Serdy, Kahn, & Goldfine, 2004). Then, glucose in the form of glucose 6-phosphate is primarily used in one of three pathways: oxidation to pyruvate, storage in the form of glycogen (a polypeptide of glucose molecules), or conversion to other sugars and intermediates that can be used in other pathways required by the body (Bouche, Serdy, Kahn, & Goldfine, 2004). The pathway that produces pyruvate will fuel the Krebs cycle which produces 38 molecules of ATP per molecule of glucose under aerobic conditions (Bouche, Serdy, Kahn, & Goldfine, 2004). Under anaerobic conditions glucose can provide ATP to skeletal muscle, but only at a rate of 2 molecules of ATP per molecule of glucose, thus it is not primarily used by the body when it needs energy (Bouche, Serdy, Kahn, & Goldfine, 2004). The second pathway of glucose is storage as glycogen primarily in the muscle and liver. The muscle stores it to be able to perform contractions throughout the day and the liver stores it in order to maintain constant blood glucose levels (Bouche, Serdy, Kahn, & Goldfine, 2004). The glucose is taken up from the blood and stored in this form until it is needed, like when a person is sleeping and they need to
maintain a normal blood sugar level due to going without food for eight hours (Bouche, Serdy, Kahn, & Goldfine, 2004). The third pathway is the conversion to other products the body can use primarily in the form of glycolipids and glycoproteins. Glycolipids and glycoproteins are part of the cell membrane and play a variety of roles, such as receptors, cell signaling, and stabilization (Tauber, Reutter, & Gerok, 1987). The metabolism of glucose provides the body with energy, stable blood sugar when there are periods of no eating, and other products that help the body’s cells function normally.

Figure 1. Three pathways of glucose metabolism into glycogen, pyruvate, and other biosynthetic products from (Haukaas, Giskeodegard, Euca, & Bathen, 2017).
Another important aspect of managing Type 2 diabetes is exercise. Physical activity in those with diabetes can prevent or delay the onset of several conditions which could result in premature deaths, like cardiovascular disease or kidney and nerve disease (Colberg, et al., 2010). The American Diabetes Association along with the American College of Sports Medicine recommend at least 150 minutes a week of moderate-intensity aerobic activity as well as 90 minutes of intense aerobic activity with no more than two days between exercises (Sigal, Kenny, Wasserman, Castaneda-Sceppa, & White, 2006). Exercises should not be longer than two days apart because the best glycemic control occurs when the exercises are more frequent (Dugan, 2016). Aerobic exercise can lower blood glucose concentrations for about two to 48 hours after physical activity and improve insulin sensitivity for up to 72 hours afterwards (Dugan, 2016). The best form of exercise for those with T2DM is a mix of aerobic exercises and resistance training (Dugan, 2016). Aerobic exercise leads to an increase of blood glucose uptake into the muscles when they contract, which leads to an alternate insulin-independent pathway that helps keep blood glucose levels where they need to be (Dugan, 2016). Resistance training causes muscles to get bigger and the increased muscle mass means there is more muscle there to uptake blood glucose, therefore leading to better glucose control (Dugan, 2016). So, resistance training allows aerobic exercise to work the best it can, which is why the two are recommended to be performed together. Exercise along with diet can help those with T2DM maintain their disease so they do not get other chronic diseases, several of which could cause premature deaths.

The most important things those with Type 2 diabetes (T2DM) can do are control their diet and get plenty of exercise. However, controlling the diet can be quite complicated due to a large variety of food groups and the determination of which foods will have a positive impact. The best way to keep diabetes under control is to portion foods and make sure each meal is
balanced with proteins, dairy, grains, fruits, and vegetables. By doing so, a person can ensure they are getting all the proper nutrients they need, and they are able to keep their blood sugar at a normal level (Deed, Barlow, Kawol, Kilov, & Sharma, 2015). But, different countries have different foods, so their diets may be composed differently from one another. So, some countries may end up having lower rates of diabetes than others. I will look at countries that have lower and higher rates of diabetes and determine what they have in common and in what ways they differ in terms of diet. By doing so, I may be able to determine what type of diet allows for the best glycemic control. So, I will be looking at five different countries that have different types of diets: Brazil, China, Micronesia, Nigeria, and the United States. These countries were chosen because they are in different geographic, as well as agricultural, regions of the world, which will change the composition of each diet and should give a more distinct answer as to which parts of the diets, if any, affect diabetes rates. The five countries chosen also differ in terms of development, for example, the United States is a first world country and Nigeria is a third world country, so the types of foods as well as availability of health programs will be very different. I will break down the diets of each country and then compare them to one another to determine which components are different and which are similar to determine whether or not global diets influence the rate of T2DM.

Literature Review

According to DeBruyne et al. (2016), there are many factors to consider when planning a diet; macronutrient intake, total carbohydrate intake, glycemic index, sugars, whole grains and fibers, dietary fat, protein, micronutrients, and body weight. Macronutrients are important in controlling blood sugar levels and include carbohydrates, fats, and proteins. The daily recommended intake for these nutrients are based on the suggested intake for the general
population and are measured in percent of total kilocalories. The suggested percent for carbohydrates is 45-65%, fat is 20-35%, and protein is 10-35%. Total carbohydrate intake is the biggest factor for maintaining proper blood sugar levels, so foods like whole grains, legumes, vegetables, fruits, and milk products are favored, whereas, refined grains and added sugars should be limited (DeBruyne, Pinna, & Whitney, 2016). Glycemic control is important in diets because it allows those with diabetes to keep their blood glucose levels low by choosing foods that are high in fiber and minimally processed. Sugars can still be ingested while having diabetes, but in moderation. Some sugars that can be safely ingested are artificial sweeteners, fructose, and sugar alcohols due to them having low or no glycemic effects. Whole-grain foods provide plenty of fiber and are highly suggested for those with Type 2 diabetes because studies have shown that high amounts of fiber have improved glycemic control. As for dietary fat, monounsaturated fats are best along with omega-3 fatty acids, however, saturated and trans fats should be limited. Protein intake is suggested to be 15% of total kilocalorie intake, which is the same as the average population. Higher intakes have been suggested to improve glycemic control but can be harmful to the kidneys. The suggested intake of micronutrients for people with T2DM is the same as that of the general population, so there is no big impact of these nutrients on the control of diabetes. Finally, body weight is important in controlling blood glucose levels because an increase of body fat can lead to “insulin resistance, glycemic control,” increased blood lipid levels, and increased blood pressure, all of which have negative impacts on the body (DeBruyne, Pinna, & Whitney, 2016).

In Table 1 the daily intake of 11 food groups will be investigated along with the percentage of total calories coming from carbohydrates, protein, and fats for each of the five countries. The number of calories, percent of the population that is obese, and the percent of the
population that has diabetes will also be considered when comparing diets and their effects.

Some research will also be discussed since the cause of T2DM is based on a variety of factors outside of diet, like ethnicity or the type of healthcare available in the country. Diets may affect ethnicities differently due to their varying genetic makeup, so countries with similar diets may have differences when it comes to the percent of the population with obesity and diabetes.

Table 1. Listed are the percentages of population that has diabetes as well as those who are obese. Calories per day with the percentage of those calories that come from carbohydrates, proteins, and fats. Grams of 11 different food groups that are consumed per day.

<table>
<thead>
<tr>
<th></th>
<th>Brazil</th>
<th>China</th>
<th>Micronesia</th>
<th>Nigeria</th>
<th>United States</th>
</tr>
</thead>
<tbody>
<tr>
<td>% Diabetes</td>
<td>10.2</td>
<td>10.6</td>
<td>37.2</td>
<td>1.9</td>
<td>12.8</td>
</tr>
<tr>
<td>% Obesity</td>
<td>22.1</td>
<td>6.2</td>
<td>45.8</td>
<td>8.9</td>
<td>36.2</td>
</tr>
<tr>
<td>Calories per Day</td>
<td>3,100</td>
<td>2,970</td>
<td>3,030</td>
<td>2,710</td>
<td>3,770</td>
</tr>
<tr>
<td>% Calories by Carbohydrates</td>
<td>59</td>
<td>61</td>
<td>60</td>
<td>69</td>
<td>49</td>
</tr>
<tr>
<td>% Calories by Protein</td>
<td>11</td>
<td>12</td>
<td>10</td>
<td>9</td>
<td>12</td>
</tr>
<tr>
<td>% Calories by Fat</td>
<td>30</td>
<td>27</td>
<td>29</td>
<td>22</td>
<td>38</td>
</tr>
<tr>
<td>Processed Meat (g)</td>
<td>21</td>
<td>4</td>
<td>18</td>
<td>6</td>
<td>35</td>
</tr>
<tr>
<td>Red Meat (g)</td>
<td>83</td>
<td>50</td>
<td>55</td>
<td>25</td>
<td>41</td>
</tr>
<tr>
<td>Sugared Drinks (g)</td>
<td>117</td>
<td>13</td>
<td>139</td>
<td>72</td>
<td>274</td>
</tr>
<tr>
<td>Juice (g)</td>
<td>74</td>
<td>.2</td>
<td>29</td>
<td>2</td>
<td>96</td>
</tr>
<tr>
<td>Milk (g)</td>
<td>132</td>
<td>18</td>
<td>67</td>
<td>41</td>
<td>199</td>
</tr>
<tr>
<td>Fruit (g)</td>
<td>105</td>
<td>42</td>
<td>159</td>
<td>103</td>
<td>97</td>
</tr>
<tr>
<td>Vegetables (g)</td>
<td>56</td>
<td>257</td>
<td>217</td>
<td>118</td>
<td>87</td>
</tr>
<tr>
<td>Legumes (g)</td>
<td>188</td>
<td>17</td>
<td>2</td>
<td>82</td>
<td>19</td>
</tr>
<tr>
<td>Whole Grains (g)</td>
<td>14</td>
<td>10</td>
<td>35</td>
<td>45</td>
<td>46</td>
</tr>
<tr>
<td>Nuts and Seeds (g)</td>
<td>2</td>
<td>3</td>
<td>8</td>
<td>18</td>
<td>4</td>
</tr>
<tr>
<td>Seafood (g)</td>
<td>36</td>
<td>31</td>
<td>44</td>
<td>26</td>
<td>18</td>
</tr>
</tbody>
</table>

Note: Data for percent of population that has diabetes is from International Diabetes Federation (2017), percent of population that is obese is from Central Intelligence Agency (2016), calories consumed per day and the percent of the calories that are from carbohydrates.
carbohydrates, proteins, and fats are from FAOSTAT (2011), and the grams of food groups is from the Dietary Intake of Foods and Nutrients by Country (2010).

Each country has its own traditional diets that are usually unique and stand as a representation of their culture. However, there is one diet that seems to be sweeping throughout the world and it is referred to as a Western diet. A Western diet is one that consists primarily of dairy products, cereals, refined sugars and vegetable oils, alcohol, salt, and fatty domestic meats (Cordain, et al., 2005). A diet high in these food products results in an increase of chronic diseases including obesity and type 2 diabetes as well as many others (Cordain, et al., 2005). When people stray from a more natural diet consisting of foods their ancestors used to consume, they are putting themselves at a higher risk of getting these diseases. These types of foods have much higher glycemic load than foods that are unprocessed, like fruit, which make the body need to produce more insulin to break down the sugars (Cordain, et al., 2005). When the body is placed under this stress constantly it is likely to wear it down and increase insulin resistance.

According to Drewnowski and Popkin (1997) as incomes increase and the population becomes more urban the diets people have change from one full of complex carbohydrates and fiber to one full of fats and sugars. However, this shift of diet results in an increase of chronic diseases. The increase in economy in countries leads to them being able to import foods, have fast foods, and increase consumption of sugars and fats (Drewnowski & Popkin, 1997). So, the country’s diet slowly becomes Westernized as the economy increases which means countries with a small economy should have lower rates of diabetes and obesity. One result of an increasing economy is rapid urbanization (Drewnowski & Popkin, 1997). More people will choose to live in a town because that is where jobs are as well as food markets and health care centers. But as more people live in town they become subjected to the sedentary lifestyle full of unhealthy foods that are readily available (Drewnowski & Popkin, 1997). Thus, an urban environment tends to
produce a population with more chronic diseases than rural environments. Four out of the five countries being researched are considered developing countries, the only developed one is the United States. However, some countries are more developed than the others and are ranked accordingly: United States is 10\textsuperscript{th}, Brazil is 79\textsuperscript{th}, China is 90\textsuperscript{th}, Micronesia is 127\textsuperscript{th}, and Nigeria is 152\textsuperscript{nd} in the world (United Nations Development Programme, 2017).

Brazil

In Brazil, the northern region of the country is said to have 3.6-5.5\% of the population with diabetes and in the southern region 6.7-8.2\% of the population has diabetes (Almeida-Pitto, et al., 2015). The southern region is also the one that has a population with a higher income, which would explain why they have a higher rate of diabetes, the population there can afford to buy more food as well as food that is not necessarily healthy (Almeida-Pitto, et al., 2015). According to Coutinho and Silva Jr. (2015), about 84.4\% of the population in Brazil live in urban areas and 42.6\% live in the southern region. The populations that live in these areas are at greater risk of getting T2DM due to being in an environment where everything is readily available nearby, so they do not have to walk very far or farm for foods. As stated before, having more money can also put a population at risk because they can afford more and less healthy foods. About a third of those diagnosed with T2DM in Brazil were considered obese, about 40\% were considered overweight, and an estimated 41\% of the population does not get enough exercise to maintain proper (Coutinho & Silva Jr., 2015; Almeida-Pitto, et al., 2015). This contributes to the theory that those with more money can eat more as well as those in urban areas do not have to exercise as much, which is shown by Dugan (2016) to be an essential part in helping maintain T2DM. The high intake of soft drinks, fatty or red meats, and the low intake of fruits and vegetables account for the increase of body fat, which increases the body’s resistance
to insulin (Almeida-Pitto et al., 2015). As for the health care for diabetes in Brazil, Almeida-Pitto et al. (2015) states that diabetes patients tend to be evaluated by primary care physicians, however, these physicians feel as if they are not adequately trained to give education to patients about how to care for their diabetes. Brazil does have a free health care system implemented and it helps give those with diabetes the medical supplies needed to maintain their diabetes, but sometimes it does not give them enough or meet the needs of the specific patient, so they have to pay out of pocket for some treatment costs (Coutinho & Silva Jr., 2015). This might prevent patients from getting the proper treatments needed.

China

According to Hu and Jia (2018), those at the greatest risk of diabetes in China are those who live in urban and economically developed areas as well as those who are overweight or obese and elderly. Each one of these factors leads to people who are less active, which leads to them becoming overweight. For example, those in urban and economically developed areas have less need to grow their own foods and do not have to travel far to get things they need, and elderly people are not able to move as much as they used to so their chances of gaining weight increases along with their chances of getting diabetes. Other factors that affect the rate of diabetes in China are the fact they are eating more refined foods and fats along with the fact the Chinese develop T2DM at a much lower BMI (Body Mass Index) than other ethnicities (Hu & Jia, 2018). One factor as to why they develop diabetes at a lower BMI is that they tend to carry most of their fat around their abdomen, which has been discussed as the main area that affects insulin sensitivity (Hu & Jia, 2018). According to a study done by Xu, Luo, and Wu (2015), about 28% of the Chinese population did not receive medical treatment for their diabetes and the majority lived in rural environments. China has increased its insurance coverage so the most
likely reason those in rural environments do not use diabetes treatments is due to the proximity of health care centers (Xu, Luo, & Wu, 2015). However, the health care for diabetes in China is poor, about 60% of those with diabetes go undiagnosed which is due to how large the Chinese population is, the health care system cannot screen the entire population for prediabetes nor identify high-risk groups systematically through blood glucose tests (Weng, et al., 2016). Since the majority of the population can go without being diagnosed with prediabetes, they do not have the opportunity to try to get it under control or reverse it, so it eventually turns into T2DM (Weng, et al., 2016). The health care in general in China is good, but poor for diabetes, and this is likely due to diabetes being a new epidemic they have not faced before in such a high prevalence. The reason behind this epidemic is rapid economic development and the movement of people from rural environments to urban ones (Hu & Jia, 2018).

*Micronesia*

Prior to World War II Micronesia was primarily a country that subsisted on fishing, foraging, and some farming with little of the population being obese (Shmulewitz, et al., 2006). However, after WWII the United States sent help in the form of westernized foods that were high in fat and salt (Shmulewitz, et al., 2006). It was then after the Micronesian population started consuming these foods that they became overweight and obese which lead to the prevalence of diabetes increasing. Spain first colonized the country in 1886, and it has since been controlled by other countries making it completely dependent on other countries for food and development (Cassels, 2006). The United States has been helping them since WWII, but the foods being sent are highly westernized which is not what the islanders’ bodies are used to consuming and the development occurring has led to a more sedentary lifestyle in the population, both of which are leading to the obesity epidemic in Micronesia as well as their high diabetes prevalence. Those
with lower incomes tend to consume the imported foods that are energy-dense, such as high-fat meats and processed foods, and they cannot afford nutrient rich foods, like fish or complex carbohydrates (Cassels, 2006). One issue with the health care system in Micronesia is there is no link between health care centers (Ichihio, Anson, Keller, Lippwe, & Aitaoto, 2013). If a patient were to switch to a different place to get treated, then the staff there would have no idea how the patient was being treated at the other center which would cause difficulty with them deciding on how to treat the patient. Another issue with their health care system is the limited number of doctors on each island in ratio with the number of patients that need care (Post, 2010). The doctors do not get enough time to counsel a patient properly, which could lead to patients with diabetes not knowing how to properly care for their condition. Also, if a patient needs a more specialized doctor or treatment, then they may have to travel to another island that has a health care center that is more well equipped to treat them (Post, 2010). However, patients likely cannot afford to do this, so they may go without treatments. Another problem is that the doctors are not properly equipped to be able to diagnose patients, for example, they may be missing a stethoscope or blood pressure machines (Post, 2010). Overall, the health care system in Micronesia is not up to par with where it needs to be to treat the large number of cases of obesity and diabetes.

Nigeria

Currently in Nigeria it is estimated that diabetes is prevalent in 1% of those living in rural areas and 5-7% of those in urban areas (Ogbera & Ekpebegh, 2014). However, about half of the total population lives in urban areas, so it seems the majority of diabetes cases in Nigeria will occur in cities rather than out in the country (Ogbera & Ekpebegh, 2014). Inactivity can also increase the number of cases since it can lead to obesity and this most often occurs in the urban
areas possibly because the people there do not have to work the land to grow their own foods to survive, they can go to a store or merchant to buy foods (Azevedo & Alla, 2008). Some other factors said to impact diabetes is whether a person is wealthy or poor. In Nigeria the wealthy tend to have higher rates of diabetes, which is most likely due to the fact they can afford to buy more food and food that is unhealthy, like desserts (Azevedo & Alla, 2008). The healthcare in the country is sub-optimal since it is a developing country and as such the health insurance is not fully set up, so the majority of the population will have to pay out of pocket to get medical help (Ogbera & Ekpebegh, 2014). This may impact how often, or if at all, a person will receive medical help for certain conditions, like diabetes, which may cause the conditions to become worse and they may not receive the knowledge they need to care for their condition. According to a study done by Tekola-Ayele, Adeyemo, and Rotimi (2013), a gene called PPARG contains two alleles Pro12 and Ala12. The Ala12 allele is associated with increased insulin sensitivity along with a lower BMI which protects against T2DM, however this allele is shown to be absent or in very low amounts in Africans. The Pro12 allele is associated with increased receptor activity which allows for a bigger fat storage and is found in Africans. The absence of Ala12 puts Nigerians at risk of developing T2DM and the presence of Pro12 allows for them to survive during periods of famine, however with the urbanization and westernization this allele is no longer needed. Since the Pro12 allele is still present in the presence of abundant food sources that are high in carbohydrates and fats, this leads to an increase in obesity and potentially diabetes.

United States

In the United States some of the factors that affect rate of diabetes are the lack of physical activity, increased consumption of sugar, and obesity, especially when the fat is mainly located
around the abdomen (Stokes & Preston, 2017). Other factors to consider are the rapidly increasing senior population who cannot exercise as much as they used to and the wide range of ethnicities that are part of the United States population. Some of these ethnicities, like African Americans and Native Americans, are genetically more predisposed to getting diabetes so that will impact the overall population percentage (Kulkarni, 2004). African Americans are almost twice as likely to get T2DM than the rest of the United States population and part of that reason is because of the foods they choose to eat (Kulkarni, 2004). These foods are referred to as “soul foods” and are primarily consumed in the southern part of the country in rural and low-income areas (Kulkarni, 2004). Examples of soul foods are deep fried meats, corn, starchy vegetables, grains, and whole milk (Kulkarni, 2004). Each one of these foods are full of carbohydrates, fats, cholesterol, and sodium all of which are not good for the body in excess amounts. Part of the reason why patients will not stick to a diet health care plan is because the foods in the treatment are unfamiliar to them (Kulkarni, 2004). Immigrants to the United States sometimes acclimate to the culture here quickly and that includes the food. Rapidly changing from their traditional diet to a more westernized one in the United States has led to an increased risk of chronic diseases (Kulkarni, 2004). In the United States about 23% of people reported not having health insurance and 17% reported not having had it for over a year (Casagrande & Cowie, 2012). Without health insurance many people would not be able to afford going to the doctor, which could impact the chances of those with diabetes getting the care they need (Casagrande & Cowie, 2012). However, the ADA (American Diabetes Association) has placed a criteria list that requires individuals who meet it to be tested for diabetes (Pratley, 2013). Some criteria on the list are those who are overweight, family history of diabetes, ethnicity, signs of insulin resistance, mother had gestational diabetes, or age at which puberty begins (Pratley, 2013). By testing
people who meet these criteria a physician may be able to diagnose them with prediabetes and potentially stop the disease from progressing to diabetes. But sometimes the patients can remain asymptomatic for a long time and so their prediabetes can turn into diabetes without them or their doctor even knowing, so many people go undiagnosed (Pratley, 2013). As a result, almost a quarter of the total diabetic population, or six million, are undiagnosed and the almost 60 million people that are prediabetic may develop T2DM without realizing it (Colberg, et al., 2010).

**Discussion**

As shown in Figure 2, of the five countries examined, Nigeria has the lowest diabetes rate, but China has the lowest obesity rate. However, China’s diabetes rate being higher than their obesity rate may be due to the fact Chinese can get diabetes at lower BMIs because they tend to carry their fat around their abdomen which decreases insulin sensitivity (Hu & Jia, 2018). Micronesia has the highest diabetes and obesity rate, which is due to recent innovations of the islands becoming westernized, leading to the islanders consuming foods that they did not have in previous years, such as refined sugars and processed meats. This westernization, along with their decreased physical activity, could be what is causing the increasing obesity rate of the country, which is leading to more T2DM diabetes cases developing. Another factor that could affect them having a higher rate of diabetes is because the country is comprised of many small islands, so it is sometimes difficult to get properly diagnosed and treated for their condition. If they do not have the proper medical center on their island, then they would have to travel by boat to another island to get treated and many cannot afford to do this. In the countries studied, the United States has the second highest percentage of diabetes cases and obesity rates, which is probably due to the increasing senior population who cannot exercise like they used to, the increase of immigrants who conform to the westernized foods, and the types of food widely available, like
fast food or “soul foods”. These foods are not the best due to them being heavy in fat, sodium, and cholesterol of which could cause CVD (Kulkarni, 2004). Finally, China and Brazil are in the middle with their percentages of diabetes being very close at 10.6% and 10.2%. China and Brazil having similar percentages of those with diabetes could be due to them being close to each other in terms of having high development. Micronesia has the second lowest development out of the five countries, but they are dependent on the United States for many things, food included. Because they depend on the United States for food, they are consuming foods that are highly westernized and are high in fats and sugar. This new diet has caused the local population to become obese very quickly and due to lack of proper health care diagnosing prediabetes more diabetes cases occur. Whereas Nigeria is the lowest in terms of development, which could be what is keeping their obesity and diabetes rates low. They have not been subjected to large amounts of western food, except the wealthy, which could be why they tend to have higher rates of diabetes compared to those in rural environments or who are poor.

![Figure 2. Percent of the population that has diabetes and the percent that is obese.](image_url)
Figure 3 shows that China and Brazil have quite similar calorie compositions, although there are slight differences in percent of total calories coming from carbohydrates and fat. However, the difference in calorie composition between China and Brazil is only by 1-3%, unlike the United States and Nigeria which have a much higher caloric composition difference of 3-16%. This could be due to Nigeria not consuming as much western food, which is the staple diet in the United States. Also, Nigeria is considered the least developed country out of the five and the United States is the most developed, which will impact the foods available to the population. The recommended levels of carbohydrates, fats, and protein are 45-65%, 20-35%, and 10-35%, Nigeria consumes 4% more carbohydrates and 1% less protein than the recommended amounts while consuming fat within the recommended range. However, the types of carbohydrates Nigerians consume are most likely more complex rather than simple due to them being a less developed country. Complex carbohydrates, like whole vegetables and fruit, contain fiber which helps the body to slow down the spike in blood glucose levels after consuming food, simple carbohydrates do not contain fiber. The other countries being more developed likely have more simple carbohydrates in their diets, so even though they fall into the guideline for daily carbohydrates, they are probably not consuming enough complex carbohydrates the body requires. Nigeria consumes Even though the other four countries fall into each of the guidelines for daily percentage of calories coming from carbohydrates, fat, and protein, they are consuming more calories than Nigeria, so their daily percentages of calories equates to a larger number of calories for each of the three groups. So, if the United States is consuming 3,770 calories and 38% comes from fat, then they are consuming 1,433 calories of fat. Whereas if Nigeria is consuming 2,710 calories and 22% comes from fat, they are consuming only 596 calories of fat. The United States is consuming almost three times as much fat as
Nigeria, therefore the number of calories consumed per day can be very crucial to a diet, especially when most of them come from unhealthy foods.

Protein and fat are the other two nutrients that the body can use for energy, however, it prefers carbohydrates as the primary source because they are easier for the body to break down and use. High amounts of fat in the diet are not good for the body because they will be stored in the body, which can be harmful if primarily stored around the abdomen. High amounts of fat can also circulate through the blood and can potentially lead to cardiovascular disease which is a risk factor with T2DM (Battle, 2009). Figure 3 shows the United States consumes the highest amount of fat with Micronesia and Brazil having the second most. The United States and Micronesia have the highest rates of diabetes. While the United States is the most developed and Micronesia is the second least they share the same diet due to Micronesia obtaining food from the United States. Brazil is the second most developed, so they have more urban areas compared to Micronesia, China, and Nigeria, which would allow the populations there to be less physically active. The urban populations do not have to travel far to obtain food or get health care. Also, the majority of the diabetes cases in Brazil tend to be in the southern region of the country where most of the wealthy population lives. This will also affect the rate of diabetes and obesity because the wealthy are able to buy more food that tends to be less healthy, whereas the poorer population cannot afford those foods, usually only native foods which are better for them. China consumes the second least amount of fat; however, the Chinese are genetically predisposed to getting diabetes at lower BMIs. Nigerians consume the least amount of fats which would help explain partly why they have the lowest rate of diabetes. They also have the least amount of people living in urban areas, possibly due to them being less developed, which is shown to have an increase of diabetes cases possibly due to people not having to travel far for food, food is
widely available, and health care is more accessible. Nigeria and Micronesia have the lowest percentages of population living in urban areas at 49.4% and 22.5% respectively with the other three countries having above 80% of their population in urban areas (Central Intelligence Agency, 2017). Micronesia’s percentage is lower; however, they tend to eat more imported western foods than Nigeria does.

As seen in Figure 4, Brazil consumes the most red meats, whereas Nigeria consumes the least. Studies have shown that an increased consumption of red meats has been linked to an increased risk of T2DM (Micha, Michas, & Mozaffarian, 2012), so Nigeria consuming the least amount could be one reason the number of diabetes cases is so low. As for processed meats, the United States consumes the most and China consumes the least. Processed meats are also bad for those with diabetes because when they are processed they gain a lot of salts or other substances, like nitrates, that help prolong their shelf life (Micha, Michas, & Mozaffarian, 2012). Nitrates used as preservatives have been shown to cause insulin resistance, so the presence of that in

![Figure 3. Percent of calories that are consumed daily as protein, fat, or carbohydrates.](image)
processed meats would be harmful to populations at risk for diabetes (Micha, Michas, & Mozaffarian, 2012). The large consumption of processed meats by Americans could explain why their obesity and diabetes rates are higher than most. However, China also has a somewhat high diabetes percentage, but they consume the least amount of processed meats. Nigeria is second lowest, which correlates with their low diabetes and obesity rates. That would also mean, however, that Micronesia should consume the most processed meats to correlate with their high rates, but this does not appear to occur. But, Micronesia has just recently begun consuming processed meats due to their dependence on the United States and most of the population consumes these foods because they are cheaper. With most of the population consuming these processed meats, there should then be an increase of diabetes cases to correlate.

![Bar chart showing consumption of red and processed meats per day per country.](image)

**Figure 4. Amount of red and processed meats consumed per day (g).**

Figure 5 shows the daily consumption of drinks in each country and that they are dramatically different due to different regulations, processing, and culture. Sugared drinks have no nutritional value and only provide the body with simple carbohydrates and calories, which need to be limited. Juice has some nutritional values, such as certain vitamins, but they mostly
contain simple carbohydrates and calories like sodas. Milk usually contains proteins, simple carbohydrates, and sometimes fats. Dairy products have been linked to a lower risk of T2DM and one of the main vitamins, vitamin D, has been shown to increase insulin secretion (Martini & Wood, 2009). The United States consumes the most in all three categories of beverages, whereas China consumes the least. Consuming the most sugared drinks and juice could be one reason the United States has such high rates of T2DM but consuming the most milk should be good because it promotes insulin secretion. Nigeria consumes the second least amount of sugared drinks, which could be the reason their rates are lower. However, they consume some of the least amounts of milk, yet they have lower diabetes cases than the other countries. So, these drinks may not be a big contributing factor affecting the rate of diabetes.

![Figure 5. Amount of sugared drinks, juice, and milk consumed per day (g).](image)

Figure 6 shows that fruits, vegetables, and seafoods are consumed in varying amounts in each country. Fruits are good to have in the diet as they provide the body with some fiber and complex carbohydrates. Micronesia consumes the most fruit and China consumes the least. Since fruit is a good food to consume, one would think Micronesia should have a lower diabetes rate
than the other countries, however, consuming large quantities of fruit can have a reverse effect and cause a person’s diabetes to become worse. This is due to fruit containing fructose, which is good for the body, but in excess can cause fructose to build up in the body and be broken down to glucose, therefore leading to high blood sugar. Next is vegetables which provide the body with fiber and carbohydrates. Both are good to have in a diet, although the amount and type of carbohydrates should be monitored. China consumes the most vegetables with Brazil consuming the least. China has one of the higher percentages of diabetes which does not correlate with high consumption of vegetables because they are high in fiber. Fiber is good for those with diabetes because it can help slow down the glycemic effects of glucose consumed. Brazil consumes less vegetables which could be why they have higher rates of diabetes. Higher consumption of vegetables should equate to a lower rate of diabetes in which case Nigeria should be the one with the higher vegetable consumption and Micronesia with the lowest. Finally, seafood contains large amounts of protein, which is essential in the diet for type 2 diabetics, so seafood should be a good food to have in a diet. Micronesia consumes the most seafood and the United States consumes the least. Studies have shown that a diet high in protein is beneficial to those with T2DM because it can decrease the glucose concentration in the blood (Gannon, Nuttall, Saeed, Jordan, & Hoover, 2003). If the diet is low in carbohydrates and high in proteins and fats, then the person could potentially control their diabetes without medications. The large consumption of seafood by Micronesia could be the cause of its higher rates because, as stated by DeBruyne, protein is important to have in a diet, but in very high amounts it can be dangerous and cause renal problems. However, the United States consumes the least amount of seafood, which could be just as bad as consuming too much because they are not ingesting as much protein from seafood as the other countries and that could be a reason they have the second highest rate
behind Micronesia. But, the United States was shown to have been in the appropriate range for protein consumption, so their lack of seafood consumption is likely not significant enough to contribute to their diabetes rate.

![Graph showing fruit, vegetables, and seafood consumption per day (g).](image)

*Figure 6. Amount of fruit, vegetables, and seafood consumed per day (g).*

Figure 7 shows the last food groups are legumes, whole grains, and nuts and seeds. Legumes tend to be high in complex carbohydrates, fiber, and protein, which are all important in a diet. Brazil consumes the most legumes with Micronesia consuming the least. The low levels of legume consumption could explain why Micronesia has a high diabetes rate because this means they are not getting as much protein and fiber as the other countries from this food. However, Micronesia is still receiving plenty of protein and fiber from other foods, like milk, meat, and seafood. Whole grains are also important in a diet because they provide the body with fiber and some protein. Fiber is shown to be important in glycemic control, so the number of diabetes cases should decrease in countries with high fiber diets. The United States consumes the most whole grains with Nigeria close to the same amount. China consumes the least whole grains. For Nigeria, the large consumption of whole grains makes sense because an increase in
consumption should equal a decrease in diabetes cases. Although it does not make sense for the United States because they also consume large quantities of whole grains, yet they have the second highest rate. Nuts and seeds are also important in a diet because they are full of protein, fiber, and unsaturated fats. Nigeria consumes the most nuts and seeds and Brazil consumes the least. Consuming nuts and seeds could be another reason Nigeria has the lowest obesity and diabetes rate out of the five countries discussed. Nuts contain fats; however, unsaturated fats have been shown to increase insulin sensitivity especially when they take the place of saturated fats (Riserus, Willett, & Hu, 2009).

Outside of diet another factor to consider when comparing diabetes between countries is the access to health care. Each of the five countries has a health care program set in place, however, the establishment of each of them is at varying levels. In Brazil there is a free health care program set in place so that the people can get treated when needed. A physician is the first person someone with suspected diabetes sees. But, the physicians do not feel well trained enough to treat those with diabetes, so this may put some of the population at risk of either not getting
diagnosed with prediabetes early enough to maintain it or those who have diabetes not getting proper treatment. Also, the health care program does not always cover the costs of treatments or medical supplies needed (Coutinho & Silva Jr., 2015). So, the people have to pay out of pocket to cover it, which could possibly prevent some who are poor from getting the treatments needed to maintain their health. In China the health care system is poor for those with diabetes, primarily due to the vast size of the population. The country cannot systematically go through and screen those at risk for T2DM and so those who have prediabetes may not even know it therefore causing them to go into full diabetes (Weng, et al., 2016). If they were diagnosed earlier, then they may have been able to prevent their diabetes through diet and exercise changes. Another reason diabetes may be high in China is the access to their health care. Those who are in rural areas have difficulty receiving treatment for their disease because most facilities are in urban areas. Diabetes is also a new epidemic for those in China due to their increase in economic development affording them access to Western foods (Hu & Jia, 2018). Also, since about 60% of those with diabetes go undiagnosed the total percentage of the country could actually be much higher than reported. This could change the results found and might allow for a more concrete answer as to whether or not global diets impact diabetes rates. In Micronesia the health care system is disorganized due to the country being comprised of many small islands. The health care facilities are not linked from island to island, so if a patient switched to another facility on another island the health care staff would not know what previous treatments they have had. Also, there is a limited number of doctors on each island, so visits are very quick, so the doctors can see as many patients as they can (Ichiho, Anson, Keller, Lippwe, & Aitaoto, 2013). This prevents an in-depth discussion of a patient’s treatment plan and so many may not know how to properly care for their diabetes, therefore causing their disease to progress. Location of facilities
is another issue. Some islands may not have a big enough facility trained to treat someone, so the patient would have to travel to one of the other islands to receive proper treatment (Post, 2010). However, the patients may not be able to afford to do so, which would also prevent them from getting proper treatments and learning how to care for their condition. In Nigeria the health care system is still being established due to the country being low in development. As a result, there is no health insurance plan set in place, which will cause people to have to pay out of pocket for treatments and medications (Ogbera & Ekpebgh, 2014). This alone would prevent many from getting properly diagnosed, causing diabetes to progress in many people. Also, the introduction of Westernized foods in Nigeria has lead to an increase in diabetes diagnoses. This is due to a drastic change from their normal cultural diet because it is high in fat and sugar, also it is more widely available, so they can eat more than what their ancestors were used to (Tekola-Ayele, Adeyemo, & Rotimi, 2013). In the United States the health care system is fully established, however, almost a quarter of the population does not have health insurance (Casagrande & Cowie, 2012). This would prevent many from getting treatments when needed and if they have diabetes, then they would have to pay out of pocket for their medication. With the price of medication this is likely to prevent many from getting the proper medications needed to help control their disease. The ADA has set several criteria for diabetes testing, and if a person meets any of these criteria, then they get screened to see if they have the disease (Pratley, 2013). However, this is flawed because many people remain asymptomatic for several years so by the time the disease is caught it has already progressed from prediabetes to diabetes. So, the health care in each of the countries has a big impact on the number of diabetes cases due to people not getting properly diagnosed, not being able to access a proper facility, or not being able to afford treatment.
Each of the five countries also have other factors that affect their diabetes rates. In Brazil, most of the cases of diabetes occurs in the southern region of the country, which contains the population with a higher income than the rest of the country. Most of the cases tend to occur in urban areas, which is also seen in China and Nigeria. Each of the three countries have higher rates of diabetes in urban cities and in those who are rich. This is most likely due to the people in urban areas do not have to travel far to obtain food as well as they do not have to grow it, they can go to a store or market and buy food. The reliance on public transportation and grocery stores with imported foods has led to the population to become physically inactive and overweight which can eventually lead to diabetes. The rich people having higher rates of diabetes also makes sense because they are able to buy Western foods available as well as more food in general. This change in diet can lead to an increase of fat storage in the body and when stored around the abdomen can increase insulin resistance causing diabetes to occur. Micronesia has been dependent on other countries since the Spanish first found it, which has caused a dramatic change in their diets. This is especially true after WWII when the United States gave aid in the form of Western foods that were high in fat and salts. Along with the development on the island causing sedentary lifestyles, the islanders slowly became obese which eventually led to diabetes to begin occurring. The split between rich and poor is also seen here. The poor tend to consume energy-dense foods and cannot afford foods good for their diet, like fish or complex carbohydrates. Factors that affect the rate of diabetes in the United States is the rapidly growing population of senior citizens and sedentary people along with the number of immigrants. Senior citizens cannot exercise like they used to, so they can be more predisposed to getting diabetes and with the number of them growing it contributes to the increase in the percentage of diabetes. Also, as technology progresses more people tend to stay indoors playing with the technology
rather than being outside moving around leading to younger people being able to develop this disease (Nightingale, et al., 2017). This change in physical activity could be one of the reasons for the high rate of diabetes in the United States. Immigrants coming to the United States affects the rate of diabetes because they conform to the Western diet quickly leaving behind their traditional diets. Changing from a traditional diet to one full of fats and sugars has been shown to lead to an increase of chronic diseases, like diabetes. Another problem in several of the countries is that some ethnicities are genetically more predisposed to getting diabetes. Chinese people will get diabetes at much lower BMIs than those who are Caucasian, which is due to the Chinese carrying most of their fat around their abdomen. Africans are also at higher risk of getting diabetes when they stray from their traditional diet to a Western diet. This is due to their ancestors not having access to a lot of food, so they did not eat often and now that today’s Africans have more access to food they can eat more. As a result, their bodies may reject this high caloric diet, therefore causing health problems possibly like diabetes.

After analyzing all the data there does not appear to be any definitive answer as to what parts of the diets affect diabetes rates even though Micronesia’s percentage of diabetes is almost 20 times that of Nigeria. It must be due to how the different parts of the diets work with one another and how much there is of each dietary component, as well as other factors, such as physical activity, genetics, and obesity rates. There are some parts of diets that seem to have clear differences between the countries with high rates and low rates, like the consumption of nuts and seeds and red meats. So, it seems global diets do have an impact of diabetes rates, however, the information I have found does not show a correlation between the diet of each country and their percentage of diabetes. Other factors could explain why countries have varying diabetes rates, like certain ethnic groups being more prone to getting diabetes due to genetics or a
sudden change in diet due to third world countries becoming modernized and adapting a western diet. Also, in several of the countries health care is not the best and so many people may not be able to get treated for their condition which may make the reported percentages to be skewed. As a result, the percentages presented in this paper may be wrong and the answer as to whether or not global diets affect diabetes rates might be able to be found, however we will not know this until a more thorough survey is performed in the countries.

Conclusion

The main question throughout this paper was, “do global diets affect the rates of diabetes?” This question remains unanswered due to there being no definitive answer based on the research found. A few differences that were noticeable were the consumption of red meats, seafood, and nuts and seeds in Nigeria, Micronesia, and Brazil. Micronesia has the highest rate of diabetes along with the highest rate of obesity, which could be one of the causes for the diabetes rate. Meanwhile, Nigeria has the lowest rate of diabetes. I looked at the number of calories consumed each day, as well as the composition of the calories, like carbohydrates, protein, and fats. I also looked at the consumption of 11 different food groups consumed per day in grams. Something I could do in the future would be to compare the diets of these countries from what they are today and what they used to be 100 years ago before most of them became westernized or I could look at what the diets are like 20 years in the future and compare them to now.
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