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System Dynamics of Chronic Diseases

in the Presence of Social Determinants

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ABSTRACT

Diabetes is a chronic and persistent disease that is on the rise in the U.S. in spite of medical advances and current public health efforts to address it. There is a relationship between socioeconomic factors such as poverty and education and the risk of developing diabetes and the progression of the disease.   A systems approach is employed to develop a dynamic hypothesis with a stock and flow model will uncover and analyze these relationships to gain a better understanding of the socioeconomic dynamics of diabetes. Social factors have a significant impact on health outcomes and their consideration is essential to developing policies that will help to reduce diabetes incidence.

<u>INTRODUCTION</u>

Diabetes is a persistent disease that is increasing in incidence despite medical advances, health care policies, and health care programs (). Socioeconomic factors such as poverty and education affect one's risk of diabetes and disease progression (). This thesis will analyze the complex relationship between poverty and the persistence of diabetes.

Poverty is the focus of this thesis because it is known that the discrepancies in diabetes prevalence with respect to income level persist even when evaluated within a single ethnic group. A study comparing diabetes prevalence between African Americans and whites who were of similar socioeconomic status demonstrated that there was not a significant difference in diabetes prevalence between the two racial groups, but there was a much stronger correlation between diabetes prevalence and other factors such as age, education, income, and body mass index (Signorello, Schlundt, Cohen, Steinwandel, Buchowski, McLauglin, Hargreaves, & Blot, 2007). These ~~statistics~~ findings suggest that race and ethnicity are not the dominant factors in the prevalence of diabetes; social factors such as poverty play a more dominant role in diabetes prevalence. The disparities among different ethnic groups are not based solely on genetic or biological differences; the environment, societal factors, and health related behaviors also play a part in fostering health disparities (Nakamura, 2003). These factors include but are not limited to poverty, lack of health insurance, education, literacy, cultural differences, and language gaps.

According to the Merriam-Webster dictionary, poverty refers to "the state of one with insufficient resources", which can include both monetary and material resources. For the purpose of this thesis, the household income will be used as a surrogate measure for the level of poverty. Peter Daniels(2006) acknowledges that "diabetes is in many respects a disease of poverty" as it is proliferates due to lifestyle and living conditions rather than a living organism such as bacteria for which antibiotics could be developed (Daniels, 2006p.). There is a connection between income and diabetes incidence. Figure 1 (Kaplan, 2009) shows the percent of adults who have diabetes categorized by income. In Figure 1, income percentage is based on the poverty threshold. For example, if the income is below the poverty threshold, it will be below 100% of the poverty level and if the income is twice the poverty level, it will be 200% of the poverty level.
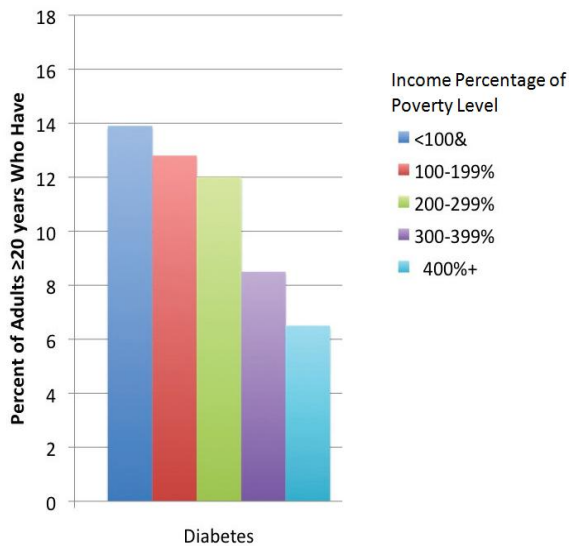
Figure 1. Percentage of people in poverty in relation to income

(Adapted from Kaplan, 2009)

Clearly, those with income levels below or at the poverty level have the highest percentage of diabetes prevalence, and this prevalence decreases as income increases. The adults with income levels at or below the poverty level are twice as likely to have diabetes as those with the highest income levels (Kaplan, 2009).

Poverty affects diabetes related health outcomes in various ways. First of all, poverty affects one's ability to afford health care (Kaplan, 2009). Inability to access health care, can lead to a more rapid progression of the disease. Also, poverty also affects one's ability to acquire proper nutrition which can increase one's risk of diabetes and facilitate disease progression (Daniels, 2006). Poverty status is known to limit opportunities for educational achievement, which can affect one's own health care regimen (Kaplan, 2009).

If the complex relationships between poverty and diabetes can be better understood, this might lead to more effective public health policy that can reduce the poverty-related disparities with respect to this disease. In this thesis, the relationships between poverty and disease prevalence will be analyzed with respect to the persistent progression of Type 2 diabetes. A dynamic hypothesis will be developed to explain the dynamics giving rise to the poverty-based disparities in diabetes. This hypothesis will be represented in part by a conceptual stock and flow model using the methods of System Dynamics (Sterman, 2000). Finally, the model structure will be analyzed to gain insights to guide policymakers who seek to reduce the prevalence of diabetes and reduce the poverty-related discrepancies described earlier. The hope is to provide a basis for more effective policies that can reduce the incidence and severity of diabetes.

The thesis is organized as follows:

- Chapter 1: Background information explaining why improvements health care alone will not solve the problem of increasing diabetes prevalence and the dynamic nature of diabetes related health outcomes

- Chapter 2: Literature review analyzing the relationship between poverty and diabetes prevalence

- Chapter 3: Development of an explanatory model that describes the relationships outlined in the literature review and how these relationships lead to policy resistance and the persistence of diabetes prevalence

- Chapter 4: Discussion of the model and its implications in policy development

BACKGROUND INFORMATION

This section describes the socioeconomic discrepancies that are present in health followed by an analysis of the development of chronic diseases, giving special attention to diabetes. Finally, the significance of a systemic analysis of diabetes related health outcomes is examined.

Socioeconomic discrepancies, medical advances, and the persistence of diabetes

There are large and growing differences in health among socioeconomic groups in several countries including the United States, Canada, and Great Britain (). It was once widely believed that socioeconomic status did not greatly affect one's health. Since many studies of health risks controlled for differences in education, income, and occupation, such adjustments may have hidden important information about the relationships between social status and health (Mirowsky & Ross, 2005). As a result, health risk factors that were known to differ significantly between socioeconomic groups were not adequately addressed in many public health policies.

Any discussion of socioeconomic health discrepancies must consider whether advances in medicine and public health policy will help alleviate this problem. While the record shows significant improvements in health care over the past century, the data also suggest that these advances have been accompanied by a continued and persistent health outcome gradient with respect to socioeconomic status (). At the same time, there has

emerged a growing epidemic of chronic diseases such as diabetes, obesity, and heart disease, where the socioeconomic health gradient is especially pronounced (). Advances in medicine and public health policy over the past century have dramatically impacted several aspects of public health such as mortality and infectious disease incidence. However, chronic diseases such as diabetes have emerged as health practices have improved and greatly reduce the threat of infectious diseases that were common in the early 19th century (CDC, 1999). A significant gradient in the prevalence and incidence of those diseases persists in spite of these medical advances.   Diabetes is the focus of this research because it is one of the more common diseases in the United States as it affects nearly 24 million Americans and its incidence is growing (NIDDK, 2009). Diabetes is very common among the working class and impoverished communities (Daniels, 2006). Type 1 diabetes is less common, is, is often diagnosed during childhood and with this condition, the body does not make the insulin that is necessary for metabolism (Daniels, 2006). Type 2 diabetes (often called adult onset diabetes) is the most common form and occurs when the body is not able to properly use insulin (Daniels, 2006). It can be easier to manage and control than type 1, but if it is untreated or the treatment regimen is insufficient, its complications can be deadly (Daniels, 2006). Common risk factors for type 2 diabetes are obesity, physical inactivity, and family history (Daniels, 2006). Though there are over 20 million people in the US with diabetes, there are twice as many that are prediabetic, meaning that they have high blood sugar levels and have a high risk of developing diabetes in the future (Daniels, 2006). This paper will focus on Type 2 diabetes. In the next section, the emergence of chronic

diseases such as diabetes is explained and the historic trends in of diabetes prevalence are explored.

<u>Progression of health care and chronic diseases such as diabetes</u>

It is important to analyze the effect of improved health practices nationwide as it is a common assumption that improvements in overall health care will improve health outcomes for everyone. Improvements in overall heath practices during the twentieth century led to the common assumption that the impact of social status on health would be minimized. However, the discrepancies in mortality rates among social groups are increasing even though the mortality rates are declining overall (Mirowsky & Ross, 2005). Moreover, data from Great Britain, Canada, and Sweden, demonstrate that differences in health outcomes among social groups do not change even when everyone has access to basic health care (Mirowsky & Ross, 2005; Marmot). The persistence of health problems in light of increased access suggests that there is more that affects health outcomes than access to basic care. Figure 2 (Woolf, 2007) illustrates the array of factors that can impact health. This figure shows that the economic and social opportunities and resources feed a combination of environmental conditions that can override or negate efforts to improve health simply by concentrating on access to medical care or modifying personal behavior. That is, access to medical care and changing personal behavior can only be effectively addressed when the broader social and economic contexts are addressed.

Figure 2. Factors that affect health (Woolf, 2007)

Health circumstances in the United States were quite different in the early 20th century than they are today. In the last century, there has been a significant decline in deaths from infectious disease and life expectancy has increased (CDC, 1999). Following the control of infectious diseases and ailments in the U.S. through improvements in hygiene and sanitation, there was an increase in the incidence of chronic diseases, of which diabetes is one specific example (CDC, 1999).

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A report from the Centers for Disease Control (2006) notes the increasing trend in the number of Americans diagnosed with diabetes and that diabetes is much more prevalent in areas where the obesity and poverty rates are higher. Table 1 shows the number of Americans diagnosed with diabetes in 5 year intervals from 1982 to 2007 in comparison to the population growth during those years.

Year	United States Population in millions	Percent Population Increase	Americans with Diabetes in millions	Percent with Diabetes
1982	231	-	5.7	2.47%
1987	242	4.55%	6.4	2.64%
1992	254	4.72%	7.5	2.95%
1997	267	4.87%	9.4	3.52%
2002	288	7.29%	13.6	4.72%
2007	301	4.32%	17.9	5.95%

Table 1. Americans diagnosed with Diabetes from 1982 to 2007 compared to US population (CDC, 2006), (US Census Bureau, 2010)

As seen in the table, as the population increases, the percentage of Americans diagnosed with diabetes continues to increase. Even with the large growth in population between 1997 and 2002 of 7.29%, the percentage of Americans diagnosed with diabetes increased from 3.52% to 4.72%. This suggests that current approaches to reduce diabetes

prevalence have not been effective. A systemic approach may help to mitigate the diabetes epidemic.

<u>Significance of a systems analysis of the socioeconomic factors that affect diabetes</u>

The relationships between poverty and diabetes are intricate and multifaceted. Poverty helps perpetuate and is reinforced by a living environment that exacerbates health risks (). Those risks in turn result in greater incidence of diseases like diabetes. The higher rates of diabetes among the poor create financial and physical stresses that inhibit the capacity of that population to take practical actions to improve their financial status (). The following sections will draw on the literature to describe this interplay between poverty and diabetes. Throughout the discussion, the methodology and language of system dynamics will be used to build a qualitative systems model that translates the findings from the literature into a model that can be tested via simulation model in future research.

Relationships between income, social factors, and diabetes are complex because some variables are endogenous, meaning that they are influenced by other factors within the system (Epstein et al., 2009). Poverty induced stress can create physiological reactions that can facilitate the progression of the disease. Both poverty induced stress and disease progression can lower one's capacity for problem solving and affect disease management (). A reduction in self management can aggravate disease progression and can deter educational achievements. In the literature review, the relationship between diabetes prevalence, incidence, and progression will be analyzed with respect to poverty.

Though social factors have a significant impact on individual health, they are often excluded from health care policies and medical research (Link & Phelan, 2005). In the United States, individualism is highly valued (Morone, 2005). In the last several decades, efforts to improve health problems focused on risk factors and individual behaviors that lead to these risk factors (Link & Phelan, 2005). This approach is helpful in some ways, but detrimental in others. Focusing on the individual behaviors can help to improve the overall health of the population one person at a time and can provide essential information to help individuals take better care of themselves and manage diseases. However, this approach ignores the impact of social factors that can also have an impact on health outcomes (Link & Phelan, 2005). By focusing on individual risk factors alone, the health discrepancies between social classes are overlooked and not taken into account when policies are made or when research is performed (Link & Phelan, 2005). Therefore, policies that focus on reducing risk factors in an individual basis will not to reduce the health discrepancies that are evident between social classes (Link & Phelan, 2005).

<u>Systems dynamics modeling and diabetes</u>

Other researchers have analyzed diabetes using a systems modeling approach. One system dynamics modeling effort was sponsored by the Division of Diabetes Translation and the Division of Adult and Community Health at the Centers for Disease Control and Prevention. This model examined the past and future trends of diabetes (Jones, Homer, Murphy, Essien, Milstein, and Seville, 2006). This model showed that an

interesting phenomenon has occurred between 1980 and 2004 with regard to Type 2 diabetes prevalence. The rise in obesity prevalence coupled with efforts to reduce the number of diabetes related deaths through disease management causes leads to an increase in the number of people living with diabetes (Jones et al., 2006). Health care providers have increased the amount of glucose screening and clinical management for diabetes patients and have encouraged individuals to monitor their disease closely; this helps to slow diabetes progression and to avoid developing complications. However, the rate of people that are being diagnosed with diabetes is not decreasing. As people are able to live longer after they have been diagnosed, but when nothing is done to reduce the rate of diabetes onset, the diabetic population continues to increase (Jones et al., 2006). This demonstrates that more attention needs to be placed on more than disease management in order to reduce diabetes prevalence. However, social disparities are not investigated in this study.

Another systems dynamics model used to analyze diabetes was developed to encourage a community focus in order to improve self management capabilities and minimize health disparities (Jenkins, Pope, Magwood, Vandemark, Thomas, Hill, Linnen, Beck, & Zapka, 2010). While the direction of this research is similar to this thesis, this model focuseds on the disparities related to minority status. A different systems modeling endeavor evaluated chronic illnesses within the United States health care system (Homer, Hirsch, Minniti, & Pierson, 2004). Their model was designed to help create a more effective, and cost efficient program for patients with chronic illnesses (Homer et al., 2004). Their study included health care utilization, cost, mortality rates, and disability rates. Again, but social dynamics are not factored into the study.

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Other diabetes modeling efforts focus on the medical and biological aspects of diabetes. One such model was developed to predict the optimal regimen for insulin injections by analyzing blood glucose levels (Stahl and Johansson, 2008). This research is limited to disease management, not prevention. While systems dynamics models have been developed to study different aspects of diabetes and health care, a model that analyzes diabetes prevalence in terms of poverty and socioeconomic status is a new approach.

METHODOLOGY OF SYSTEMS DYNAMICS

Systems dynamics modeling is a method to analyze and understand complex systems that have feedbacks within the system (Systems Dynamics Society, 2009).   It is a way to explain, model, and predict the behavior of systems involving both positive and negative feedback processes. A positive or reinforcing feedback loop amplifies changes in the system while a negative feedback loop works to balance system changes in order to maintain equilibrium.   For example, poverty conditions can create physiological stress that can increase a person's risk of developing type 2 diabetes (Daniels, 2006). When a person develops diabetes, personal medical expenses increase which can exacerbate poverty conditions. This self-reinforcing behavior creates a vicious cycle that can be very difficult to overcome through policies aimed primarily at modifying individual behaviors without considering the impact of poverty-related stress. Moreover, the effects of such relationships may take many years to play out, making it difficult to predict outcomes from a given policy.

A full systems dynamics modeling project involves problem articulation, a dynamic hypothesis, formulation of the model, testing the model, and evaluation. This thesis will include a problem articulation, dynamic hypothesis with a conceptual model that provides the foundation for a working model. Future modeling projects can continue with this work to create and test a working model.

Problem articulation describes the issues that the model will address and establishes the model boundaries. Model boundaries are especially important as the goal

Comment [t3]: I'm not sure if the following should go after the next few paragraphs. I think an overview of systems modeling first would be better.

Comment [t4]: you need a transition sentence as medical expenses are not a self-reinforcing behavior.

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of a modeling endeavor is to examine a set of concerns and simplify the real system so that it is more comprehensible (Sterman, 2000). A dynamic hypothesis is developed after the problem has been defined. It is a theory that explains the behavior of the system and how the problem evolved using the feedbacks, stocks, and flows within the system (Sterman, 2000). Stocks represent the accumulation of resources or entities within the system and flows are the rates of accumulation within the stock. Since they are rate of change, flows can either be positive, increasing the amount of resources in the stock, or negative, decreasing the amount of resources in the stock. However, as stocks represent the actual resources, they must always be positive in order to conserve matter and comply with the laws of physics (Sterman, 2000).

A dynamic hypothesis is often constructed using information from interviews and personal conversations with people involved in the system being studied and archival data (Sterman, 2000). In this thesis, scholarly articles, popular articles, magazines, books, medical journals, and other literature sources provide the basis for understanding the system.

After the dynamic hypothesis is constructed, a simulation model is created using equations, stocks, and flows (Sterman, 2000). Once a model is developed, it is analyzed to determine whether it is consistent with real world behavior and to ascertain that the laws of physics such as conservation of matter are met. Finally, once the model has been tested and validated, it can be used to create new policies and assess current policies (Sterman, 2000). This thesis will offer some considerations for future policy making procedures based on the conceptual model.
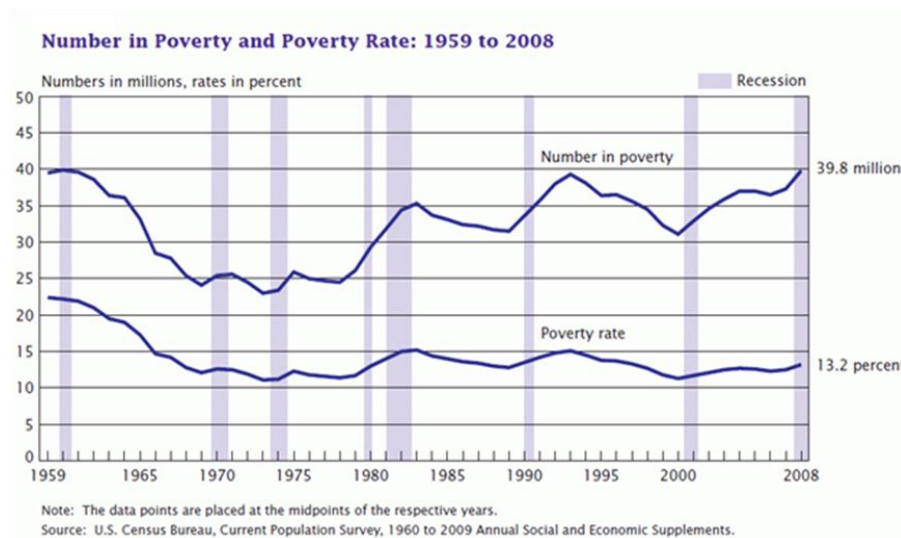
LITERATURE REVIEW

The literature review describes the prevalence of poverty in the United States and the relationship between poverty and diabetes risk factors such as obesity. ~~Next t~~The social perspective of the relationship between social class and obesity is <u>also</u> analyzed. This relationship is important because obesity is often considered an individual problem and not a social issue. ~~This is followed by a~~<u>A</u>n examination of the relationship between economic status and diabetes prevalence <u>follows with</u>~~,~~ a further analysis of diabetes risk factors, and their relationship with poverty. Next, the social factors such as education that are affected by poverty are analyzed with respect to diabetes prevalence. Finally, the financial aspect of diabetes is explored within the context of poverty and some explanations are given for the persistence of diabetes prevalence.

Prevalence of poverty in the United States

Poverty is defined by a monetary threshold set by the Census Bureau <u>(2009)</u>. The Census Bureau <u>(2009)</u> uses this threshold to determine the number of people in poverty in the nation and for economic classification ~~(US Census Bureau, 2009)~~. The Department of Health and Human Services <u>()</u> defines poverty guidelines which determine whether a person is able to receive federal assistance. Data for the number of people below the poverty threshold and the poverty rate from the Census Bureau (2009) is illustrated in Figure 3.

Since 1969, there has been a general increasing trend in the number of people in poverty (US Census Bureau, 2009). However, the poverty rate fluctuated slightly between 1969 and 2008, increasing to a maximum of about 15% and a low of about 11%, but overall the rate remained fairly stable. The 2008 rate is about the same as the rate in 1969 at 13.2 percent. As previously shown in Figure 1 (), the prevalence of type 2 diabetes is highest in low-income groups and lowest in high-income groups. This, coupled with the fact that diabetes is on the increase as shown in Figure 3, suggest that the dynamics behind the relationship between income level and diabetes need to be better understood.

Number in Poverty and Poverty Rate: 1959 to 2008

Numbers in millions, rates in percent   Recession

Number in poverty   39.8 million

Poverty rate   13.2 percent

1959   1965   1970   1975   1980   1985   1990   1995   2000   2008

Note: The data points are placed at the midpoints of the respective years.
Source: U.S. Census Bureau, Current Population Survey, 1960 to 2009 Annual Social and Economic Supplements.

Figure 3. Percentages and number of people below the poverty threshold (US Census Bureau, 2009)

Relationship between poverty and obesity

The highest rates of obesity are found among the most disadvantaged groups, meaning those with low levels of education and income (Drewnowski, 2009). One reason for this is that nutritious, high quality foods are more expensive than foods that are less healthy and contain higher amounts of fat and sugar. Therefore, when income in low it is more difficult to maintain a nutritious diet (Drewnowski, 2009).

Increases in obesity in the United States have been attributed to higher consumption of foods with added fats and sugars, refined grains, snacks, and fast foods (). Fast foods chains and convenience stores are more common near areas of low income than supermarkets and grocery stores that provide healthier food options (). Restaurants and fresh produce are more plentiful in more affluent areas (Drewnowski, 2009). Fast food chains and convenience stores typically have foods that would contribute to obesity, while restaurants and supermarkets offer a variety of options including healthy foods (Drewnowski, 2009).

Supermarkets are a more dependable and more economical source of healthier foods such as fresh fruit and vegetables than grocery stores (Kaplan, 2009). A grocery store mainly sells food while a supermarket carries a large variety of items including food, clothing, and household items. Supermarkets are larger than grocery stores and have more options and more items available than grocery stores (Supermarket, 2008).

In low income neighborhoods, convenience stores and grocery stores are more common than supermarkets compared to middle income neighborhoods (Kaplan, 2009).

Convenience stores mainly offer essential items and do not focus on quality or variety of food. They are often found on busy roads or with gas stations (General Store, 2008). For example, in Manhattan's Upper East Side, which is a wealthy area of New York, food stores were three times as likely to supply healthier foods such as breads that are high in fiber and low fat dairy products than stores found in East Harlem which is a poorer community with a median income of around $20,111 (Daniels, 2006). The median income in East Harlem is about one fourth of the median income for the Upper East Side (Daniels, 2006).

It is often thought that obesity is only caused by consistent overeating since obesity occurs when more energy is put into the body than is exerted. However, obesity can be present in those who experience food insecurity (Center on Hunger and Poverty and Food Research and Action Center, n.d.). Food insecurity exists when there is limited or erratic access to healthy and nutritious food (Center on Hunger and Poverty, n.d.). When faced with food insecurity, which is common among people in poverty, food of poor quality that is less expensive is purchased in an attempt to have food on a regular basis. In order to have an acceptable caloric intake, foods of high caloric value but low nutritional value are consumed (Center on Hunger and Poverty, n.d.).

Food insecurity affects the amount of food consumed as well as the quality of food consumed. When food is scarce, much less food is consumed or more foods that are high in energy and high in fat are consumed (Center on Hunger and Poverty, n.d.). When food becomes available, people experiencing food insecurity tend to eat more than normal after a period of food scarcity (Center on Hunger and Poverty, n.d.). Such frequent changes in eating habits can encourage weight gain because physiological

changes occur that encourage the body to store more calories as fat to compensate for the times when calories are not being consumed (Center on Hunger and Poverty, n.d.).

The food stamp program is designed to alleviate the strain of food scarcity and minimize food insecurity. Food stamps are administered by the Supplemental Nutrition Assistance Program (Supplemental Nutrition Assistance Program [SNAP], 2010). Once a household is approved to receive food stamps, the stamps are provided on a monthly basis and offer an average $0.79 per meal per person (Center on Hunger and Poverty, n.d.). Unfortunately, this amount is not enough to supply nutritional healthy foods and the money may not last until the next distribution of food stamps. Toward the end of the month, before the food stamps are provided again, food can become scarce causing the people to eat less often and eat food of poorer quality both of which can facilitate obesity (Center on Hunger and Poverty, n.d.). Once food stamps are offered again and there is more food available to eat, people will change their eating habits once again (Center on Hunger and Poverty, n.d.).

Another issue arises as all stores are not eligible to accept SNAP benefits. There are two ways in which a store is eligible. In order to meet the first set of eligibility criteria, a store must offer at least three different types of food from each of the four basic food groups and perishable food in at least two of the four categories (SNAP, 2010). If a store wishes to meet the second set of eligibility criteria, at least half of the total sales in the store must be from eligible staple foods (SNAP, 2010). Foods that are eligible for purchase through the SNAP program are household foods such as bread, cereal, fruits, vegetables, meat, and dairy products. Seeds that can be used to grow food can also be purchased with SNAP program funds (SNAP, 2010). However, hot foods, food that will

be consumed while in the store, alcoholic products, tobacco products, vitamins, medicine, and non food items are not eligible for purchase through the SNAP program (SNAP, 2010).

The correlation between low income and obesity is stronger among women than men (). This could be because women often sacrifice any food they may have eaten to make sure that her children and family have food. This will worsen the effects of food insecurity among the female population, making them a higher risk for obesity when faced with food insecurity (Center on Hunger and Poverty, n.d.) due to the reasons stated above.

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Social perspective of the relationship between social class and obesity

Overall, researchers and policy makers in the United States do not indicate social class and income as important factors that can lead to obesity (). Instead, resources and research have focused on genetics, race, personal responsibility, and free will as causes of obesity (Drewnowski, 2009). One ~~consensus~~ premise is that the majority of Americans could maintain a healthy diet but have simply decided not to do so (). This leads public effort to encourage different food choices that are healthier and to focus on people's willingness to change and psychosocial elements (Drewnowski, 2009). It leaves obesity as a problem for the individual to figure out and places blame on the person for being obese instead of viewing obesity as a community or social issue.

Some have assumed that everyone in the United States has equal access to some sort of nutritional food and healthy foods are similar in price to unhealthy foods

(Drewnowski, 2009). However, this is a flawed assumption since obesity and economic status go hand in hand. Food prices have increased, especially in recent years. The increase in food prices further limits the ability of poor families to maintain a healthy diet due to limited access, as stated previously. Also, it this increase in food prices can make it difficult for families that could once afford healthy foods to continue to afford them (Drewnowski, 2009).

<u>Relationship between economic status and type 2 diabetes</u>

There are many different factors that can contribute to the development of diabetes. However, two of the most common factors are obesity and economic status (Black, 2002). Living in a low economic status such as poverty can affect one's propensity for obesity, affects lifestyle choices such as diet and exercise, and can impair one's ability to maintain a proper regimen of care. The effects of economic status and other social factors are illustrated in Figure 4 (Black, 2002).

As demonstrated in Figure 4 (), economic status is a social factor that affects other risk factors of diabetes. Economic status can affect behavioral factors such as diet and exercise, which can impact obesity. A low economic status can elicit psychosocial reactions such as depression that can worsen disease progression. Economic status can also affect the quality of one's care regimen which also affects disease progression (Drewnowski, 2009).
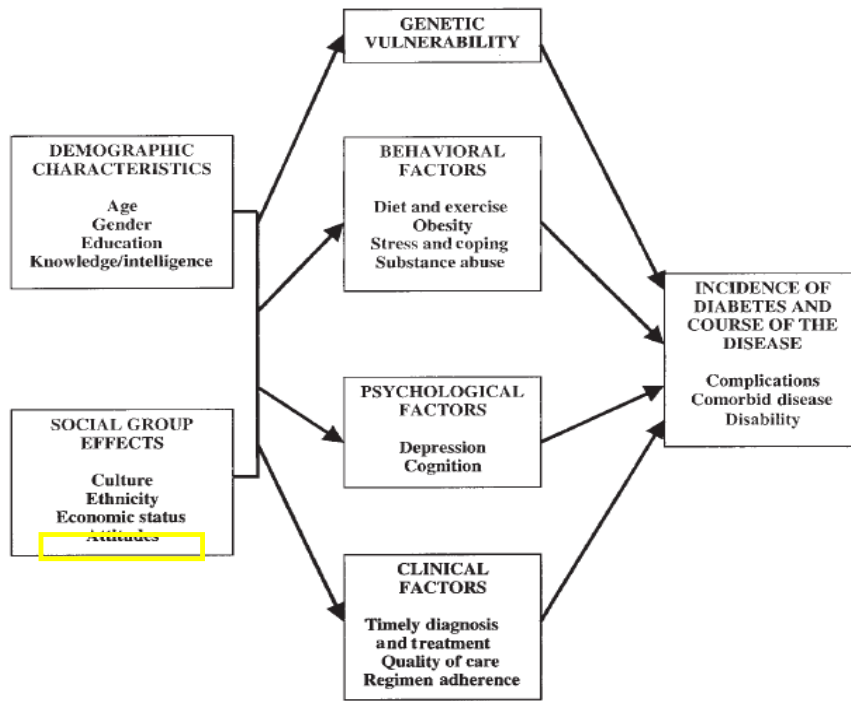
Figure 4. Risk factors for diabetes (Black, 2002)

Obesity as a risk factor for type 2 diabetes

Obesity is a widely recognized risk factor for type 2 diabetes (). Obesity is related to an inflammatory response that sets processes in motion that facilitate hyperglycemia, which means there is a high amount of sugar in the blood (Wellen & Hotamisligil, 2005). Hyperglycemia places a person at risk of developing type 2 diabetes and can create complications in those diagnosed with the disease.

Conditions such as diabetes are metabolic disorders. The metabolic system utilizes stored energy to create a normal inflammatory response (Wellen & Hotamisligil, 2005). Storing energy is an important survival technique as this stored energy can be used during times when extra energy is needed or when an acceptable amount of nutrients is unavailable. However, stored energy is often stored as fat, which can lead to obesity when not utilized.

Obesity is associated with inflammation through the inflammatory cytokine TNF-α (). This cytokine is overproduced in the muscle tissue and adipose of humans that are obese. Studies have shown that an abundance of TNF-α gives rise to insulin resistance (Wellen & Hotamisligil, 2005).   Insulin resistance can lead the development of type 2 diabetes. Obesity has been categorized as a state of mild yet constant inflammation.

Lipids also contribute to inflammation and metabolic processes. Obesity also involves higher levels of lipids in plasma. High lipid levels also contribute to insulin resistance (Wellen & Hotamisligil, 2005).

Comment [t7]: This section needs to be reorganized. Its choppy.

Stress as a risk factor for type 2 diabetes

While there is limited data showing the correlation between stress and diabetes in humans ~~because human stress studies are difficult to perform~~, several animal studies demonstrate that stress can negatively impact glycemic control which will affect blood glucose levels (Surwit, R. & Schneider, M., 1993).

Stress impacts the brain and other physiological systems and often has a part in chronic diseases such as diabetes (Kaplan, 2009). Hyperglycemia can occur when a mouse is

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subjected to a slow intravenous infusion of epinephrine and stress similar to an extended sympathetic nervous system response (Surwit, R., & Schneider, M, 1993).

Animal studies have demonstrated that stress, especially chronic stress, can increase the production of neuropeptide Y, which is a chemical that stimulates fat cell growth (Kuo, ~~Kitlinska, Tilani, Li, Baker, Johnson, Lee, Burnett, Fricke, Kvetnansky, Herzog, & Zukowska, Z~~et al., 2007). Fat cell growth will increase one's risk for obesity, which is a risk factor for diabetes. In one study, a group of mice was placed in stressful situations and monitored while another group of mice served as the control group (Kuo et al., 2007). The mice that were stressed produced more neuropeptide Y than the mice in the control groups and experienced growth in the abdominal fat pads. When a mouse was fed a high fat, high sugar diet and under stress consistently, it experienced a large increase in abdominal fat. The correlation was stronger when stress and unhealthy diet were combined than in mice that were only fed an unhealthy diet and not placed under stress or only under stress and still fed a normal diet (Kuo et al., 2007).

Stress hormones impact the body's ability to metabolize glucose (Surwit & Schneider, 1993). Figure 5 shows that the ~~6~~ six stress hormones listed ~~all~~ each raised blood glucose levels and 4 out of the 6 decreased glucose utilization, increased glucose production in the liver, and increased insulin secretion (Surwit & Schneider, 1993). However, epinephrine can be both beneficial and detrimental to insulin secretion levels. When epinephrine levels are low, insulin secretion is increased, but when epinephrine levels are high, insulin secretion is inhibited (Surwit & Schneider, 1993).

Hormone	Insulin	Hepatic glucose production	Glucose utilization	Lypolysis	Blood glucose
Acetylcholine	↑	↑	—	—	↑
Norepinephrine	↓	↑	↓	↑	↑
Epinephrine	↑↓	↑	↓	↑	↑
Cortisol	—	↑	↓	↑	↑
Beta-Endorphin	↓	—	—	—	↑
Growth hormone	—	—	↓	—	↑

Figure 5. The effect of stress hormones on glucose production and metabolism

(Surwit & Schneider, 1993)

Stress can cause disruptions in the sleep cycle (Phillips, 2008). An inadequate amount of sleep can make weight control more difficult, increase the risk of heart disease, and increase insulin resistance. An increased insulin resistance can increase the possibility of developing diabetes and makes diabetes management more difficult (Phillips, 2008). Diabetes can also lead to other sleep complications such as nocturnia, which causes the person to have to go to the bathroom during the night (Phillips, 2008).. Waking up multiple times during the night disrupts sleep. (Phillips, 2008).

Relationship between poverty, stress, and diabetes related health outcomes

As shown, Sstress can worsen a person's health and increase one's risk of developing type 2 diabetes. Studies demonstrate that there is a correlation between material conditions and psychological strain related to poverty (Daniels, 2006). People who are poor often experience acute and chronic stress due to frequent financial troubles, food insecurity, inadequate schools for children, unsafe or uncomfortable living

conditions and surroundings, undesirable working conditions, and struggling to survive on a regular basis (Kaplan, 2009).

About 7.5 million adults work 27 weeks or more, but earn an income that is below the poverty line (Kaplan, 2009). About 66% of these adults worked full time. They often have service jobs that earn low wages and do not have as many benefits such as insurance coverage and ~~the freedom to take days from work~~paid leave (Kaplan, 2009). Others who are not able to find full time jobs are unemployed or ~~have part time jobs that pay even less than full time jobs~~underemployed. Figure 6 illustrates the disparities in the work environment between low income workers and workers with a high income (Kaplan, 2009). Those who are in the lowest 25% of income in the United States have the fewest opportunities for sick leave, vacation time, or time off for family needs such as a sick child (Kaplan, 2009).
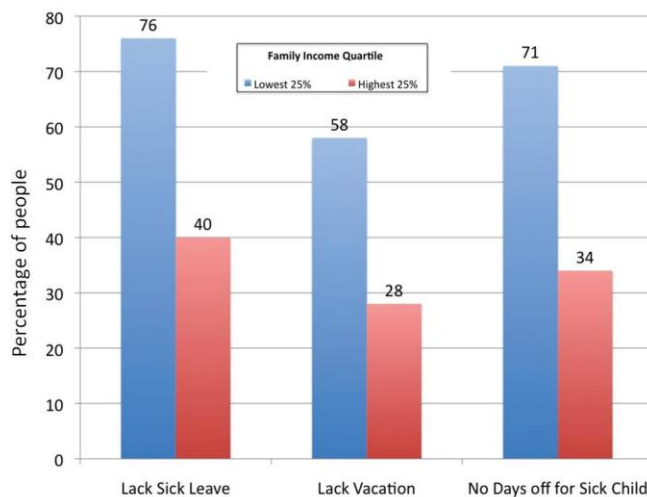
Figure 6. Percentage of work standards available for high income and low income families

(Adapted from Kaplan, 2009)

Income inequality, which refers to one's income in relation to the income earned by those in the same workplace or community, can lead to anxiety, isolation, personal insecurity, and depression (Zheng, 2009). Simply because someone does not earn high wages and has not achieved a high educational level does not mean that this person will be surrounded by others in the same situation. He or she may work and live in proximity to people who have more education and earn more money.

Jobs held by people in a low socioeconomic status do not offer the same standards as other well paying jobs and are more likely to be hazardous and unsafe (Kaplan, 2009). Poverty and the restrictions of personal expression in the work environment can lower one's perception of usefulness and autonomy, which will have a negative impact on one's health (Mirowsky & Ross, 2005). The person may begin to lose the sense of purpose, feel helpless about the events and problems that occur in life, and will not be motivated to actively manage his or her personal health nor to work towards a better understanding through education (Mirowsky & Ross, 2005).

> **Comment [t8]:** Word choice?

Working conditions for those that receive low wages can be hazardous and or unsafe (Kaplan, 2009). Working in unsafe conditions can impact one's health through exposure to harmful substances or physical injury. Also, job insecurity, arduous tasks, and having little say about working conditions creates stress which can worsen the health of the workers (Kaplan, 2009).

According to Smith's (2004) evaluation of data provided by the Health and Retirement Study in the early 1990s, health problems such as diabetes can diminish a person's ability to work (Smith, 2004). In particular, increased disease progression affects one's ability to work and earn income. If a person's ability to be a part of the

workforce is impaired, income will be reduced. Prohibitive medical expenses can amplify the financial stress, further feeding the cycle of poverty.   Overall, the income losses outweighed the impact of medical expenses in the study (Smith, 2004).

Comment [t9]: What's the point here?

<u>Relationship between education, diabetes, and poverty</u>

Education affects diabetes related health outcomes and at the same time these health outcomes affect one's education. For example, people who do not have at least a high school education have poorer health than those that have a high school or at least some college education, as illustrated in Figure 7 (). Health continues to improve as education achievements increase (Woolf, 2007).
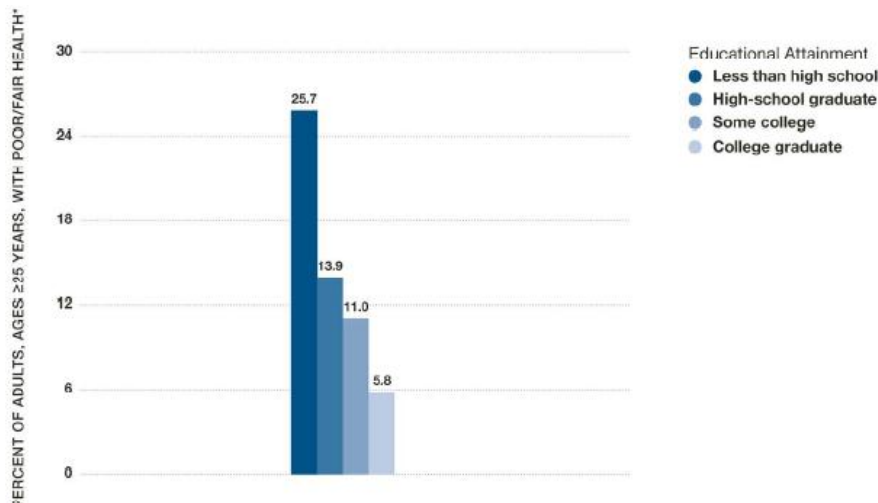

Figure 7. Comparison of health and educational attainment (Woolf, 2007)

There is a strong association between education and self management of health problems such as diabetes (Mirowsky & Ross, 2005). Education provides resources for and awareness of preventive tactics and risk factors for the disease while encouraging a lifestyle that entails healthy habits. The capacity for self management is affected by education. Self management refers to an individual's capacity for problem solving and following through on lifestyle choices that maximize overall health outcomes (Lorig, 2003). The education process provides people with tools to solve problems and think critically (Mirowsky & Ross, 2005). If people are not properly informed or educated about behaviors that affect health, it may be easier for peers and community members to influence one another to participate in behaviors that are harmful to health such as smoking, high levels of alcohol consumption, and eating unhealthy foods. These behaviors can worsen overall health and can increase a person's risk of developing diabetes.

Education provides people with a sense of control, determination, and learned effectiveness, which makes them feel as if they have some power over their lives and their future (Mirowsky & Ross, 2005). Higher educational achievements facilitate higher self management capacity and lower educational achievement erodes self management capacity (Polacek & Deaton, 2009).

There are educational disadvantages to being in poverty and these disadvantages can negatively impact one's health. Education refers to the quality and extent of educational achievement of individuals in the community.   The quality of schools near impoverished communities tends to be lower than the quality of schools near communities of higher socioeconomic status (). Schools near communities with a low

socioeconomic status have more teachers with three years or less of experience, more

temporary buildings and inadequate building features than schools in areas of higher

socioeconomic status (Kaplan, 2009). These disparities are illustrated below in Figure 8

().
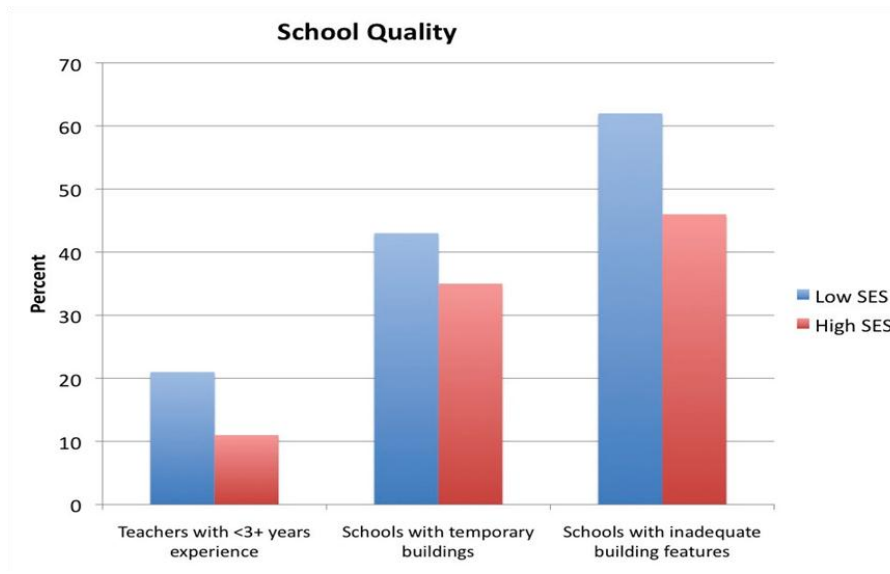
Figure 8. School quality for low socioeconomic status (SES) and high socioeconomic status

(Adapted from Kaplan, 2009)

These factors contribute to a child's learning environment. The learning

environment in schools associated with lower socioeconomic status is may be of a lower

quality than the learning environment of schools with higher socioeconomic status. These

poorer quality schools often have a smaller supply of textbooks and have lower

graduation rates (Kaplan, 2009). Thus?

Educational achievement and an individual's capacity for self management have a

self reinforcing relationship in which improvements in the former lead to improvements

in the latter, and vice versa (Mirowsky & Ross, 2005). This can lead to an either ~~virtuous~~ virtual cycle of educational achievement and behaviors exhibiting strong self management or a vicious spiral of declining educational achievement and self management.

Education affects a person's literacy level, which affects one's ability to read and comprehend information (). A person's literacy level can impact one's health circumstances. If a person is not able to read and understand pertinent health information, forms, and applications, the health process can be affected (Nakamura, 2003).

 Education not only influences one's capacity for self management, but affects poverty induced stress as well (). The effect of education accumulates and amplifies disparities over time, which creates a self-reinforcing dynamic. Education offers better job opportunities with options for creativity and self expression, which reduce the risk of exposure to the stresses induced by poverty or minimum wage jobs that do not allow for personal expression and creativity (Mirowsky & Ross, 2005).

Fortunately, a proper education can reduce the effects of economic stress as the person's ability to manage resources is improved along with maintaining a sense of control (). Stress levels are lower when available resources are sensibly allocated and the person does not feel powerless. This sense of control carries over to motivate the person to manage the disease to the best of their ability. Therefore, those with an education will fare better than others even if they have the same level of income (Mirowsky & Ross, 2005).

Comment [t10]: What does this mean?

Poverty and the expenses of diabetic care

About 25% of families that have a member suffering from diabetes spend 10% or more of their annual income on diabetic care and 8% of households spend over 20% of their annual income on diabetic expenditures (). Due to the costs of medication, equipment needed to monitor diabetes, doctor visits, hospital stays, and insurance co-pays or deductibles when applicable, 1 in 6 people with diabetes state that they skipped or delayed diabetic care (Cheng & Seshamani, n.d.).

Poverty can lead to a lack of health insurance. Health insurance is generally provided as a benefit of full-time employment. However, many employers have dropped or reduced this benefit leading to lack of health insurance coverage in working adults (Holahan & Cook, 2005). As stated above, employment opportunities are a key factor in poverty. Health insurance helps to provide access to quality health care; without it, it can be difficult to afford proper health care (Nakamura, 2003). People without health insurance typically use health services less often than those who have health insurance (Baker et al., 2001). This often means that their health care needs are not resolved or given the proper amount of attention. This leads to higher mortality rates among those who are uninsured. The percentage of families with health insurance by income level is depicted in Figure. Lack of access to health care is one of the top reasons that minority populations such as African Americans do not acquire proper health services (Nakamura, 2003).

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Poverty can hinder one's ability to access medical care. Poverty and unemployment increase the risk of health problems and can affect one's wellness as well as one's health. Those affected by poverty find it difficult to afford preventative and routine health care (Nakamura, 2003). Figure 9 () shows the percentage of people that do not have health insurance categorized by income levels. Those with the lowest income have the highest percentage without health insurance (Kaplan, 2009). As income increases, the percentage of people who lack health insurance decreases (Kaplan, 2009).
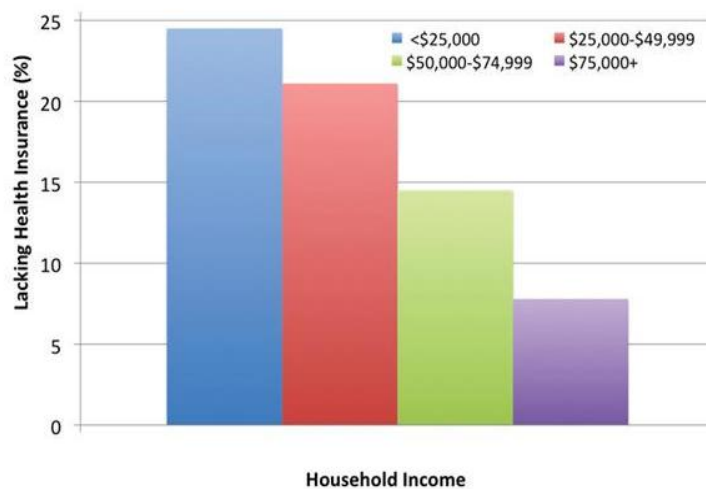
Figure 9. Percentage of families lacking health insurance categorized by income level

(Adapted from Kaplan, 2009)

Health insurance, diabetes prevalence, and overall health

It is common for health insurance companies to deter preventative treatments that would postpone the onset of diabetes or slow its progression as there is not as much of a financial gain with preventative measures (). For example, hospitals receive a $20 reimbursement for a preventative course of action such as guidance from a nutritionist and can receive up to $20,000 for an amputation which can be a necessary course of action as a result of diabetes progression (Daniels, 2006).

> **Comment [t11]:** This is a provider. How do health insurance companies fit?

In 2001, Medicare began to change regulations that kept obesity from being a disease for which patients can receive coverage(). By 2004, the Federal Center for Medicare and Medicaid Services recognized obesity as a disease (Roehr, 2004). This decision is based on scientific evidence that proves that obesity treatments are beneficial to one's overall health, regardless of its other implications as a risk factor (Roehr, 2004).

<u>Diabetes and financial expenses</u>

The American Diabetes Association estimates that diabetes cost over $132 billion nationwide in 2002, taking into account disability payments and missed working days (Daniels, 2006). The total estimated cost of diabetes rose to $174 billion in 2007 (Petersen, 2008). Direct costs associated with diabetes accounted for $116 billion and $58.3 billion was a result of lost productivity (Cheng & Seshamani, n.d.). The medical expenses for diabetic patients include hospital care, medication, supplies, retail prescriptions, and physician office visits (Petersen, 2008). Hospital in-patient care accounts for about 50% of the medical expenditures for diabetes, medication and supplies accounts for 12% of the expenses, retail prescriptions accounts for another 11% of the

total expenses, and physician office visits account for about 9% of overall diabetic expenses (Petersen, 2008).

Medical expenditures for a person with diabetes amount to an average of $11,744 annually (Petersen, 2008). Diabetic patients spend more than twice the amount of money on medical expenses than people who do not have the disease. For example, testing strips that are used to check blood glucose levels are needed daily as physicians suggest that diabetic patients check their blood glucose levels two to six times a day (Cheng & Seshamani, n.d.). A box of testing strips can cost as much as $60. Also, diabetic patients must administer insulin to regulate blood glucose levels and a vial of insulin can cost between $30 and $70 (Cheng & Seshamani, n.d.). Even if the person has insurance, these costs can be placed on the individual since insurance companies do not always cover all of the costs associated insulin administration and blood glucose testing.

Self management and diabetes progression

Self management refers to an individual's role in his or her health outcomes (Lorig & Holman, 2003). It is a concept that is associated with the daily tasks of dealing with a chronic disease such as diabetes (Lorig & Holman, 2003). Self management includes medical management of the disease, which refers to the medications and dietary decisions that affect disease symptoms (Lorig & Holman, 2003). Self management also involves creating and maintaining a lifestyle that does not exacerbate the chronic condition (Lorig & Holman, 2003). Self management also refers to the emotional aspect of a chronic disease. A chronic disease can change the way that a person perceives the

future; it can also facilitate depression, anger, fear, and frustration which can impair one's ability to make decisions and solve problems (Lorig & Holman, 2003). Overall, self management includes problem solving skills, decision making abilities, and using available resources to reduce and control disease symptoms (Lorig & Holman, 2003).

Healthy changes in behavior can affect the number of incidences of diabetes and slow disease progression for those who have already been diagnosed (). For example, healthier food choices and increasing the amount of exercise can cut the risk of a person over 60 developing type 2 diabetes in half over ten years (National Institute of Diabetes and Digestive and Kidney Diseases [NIDDK], 2009). However, once diagnosed with diabetes, an exercise regimen should be planned carefully and supported by a physician as exercise can cause blood glucose levels to decrease and can cause hypoglycemia in which the blood glucose level drops below a safe level without proper preparations and precautions (Weil, 2008).

A diminished self management capacity allows diseases such as diabetes to progress more quickly because a loss of self management capabilities leads to a lower sense of autonomy in one's life (Polacek & Deaton, 2009). Thus, Llifestyle choices will not be aimed toward optimal health outcomes and personal treatment regimens will not be as thorough. Poor lifestyle choices and inadequate treatment maintenance will intensify the progression of the disease and will further reduce one's ability for self management by further disabling the person and making symptoms more difficult to manage. Since the lifestyle choices related to health and disease management cause disease progression to worsen and reduce one's capacity for disease management, this

represents a reinforcing feedback.   The relationship between self management and disease progression is further explained in the later sections.

Likewise, improvements in problem solving capabilities help to slow disease progression, which makes the disease more manageable (Polacek & Deaton, 2009). The ability for self management is of the utmost importance when dealing with a chronic disease such as diabetes. One must work constantly to keep the symptoms under control to reduce the risk of further impairment and discomfort; this constant maintenance is often up to the patient. Self management provides one with a stronger sense of autonomy and control over his or her life (Jonker, Comijs, Knipscheer, & Deeg, 2009).   Without a lower problem solving capacity, one's health will suffer and can lead to physical and mental impairments that lower one's success at health management (Mirowsky & Ross, 2005).

Relationship between poverty, self management, and diabetes

Diabetic patients in poverty must often make difficult financial decisions, such as to spend money on medical supplies such as insulin or testing strips to check blood glucose levels or to spend the money on food and rent instead (Daniels, 2006). Many try to stretch the money as far as possible by reducing the dose of the medicine they take and cutting pills in half which makes the treatment regimen less effective (Daniels, 2006). If patients are unable to afford testing strips, they may not be able to check their blood glucose levels on a regular basis and will not be able to monitor their disease progression as well (Daniels, 2006).

> **Comment [t12]:** Your heading is poverty, self-management and diabetes. You need to have a conclusion here that ties these all together.

Why is diabetes so persistent?

Type 2 diabetes prevalence continues to persist for several reasons. First of all, the cycle of poverty is difficult to break; therefore, children born in poverty are subjected to the factors that can contribute to diabetes at a very early age (Lucile Packard Foundation for Children's Health, 2010). Since it is difficult to break the cycle of poverty, many children born in poverty remain there or move up very slightly in social class (Lucile Packard Foundation for Children's Health, 2010). Once children are in poverty, it is difficult to escape due to the lack of opportunities available and poor education which facilitates an adult life with unfavorable work situations and low income (Lucile Packard Foundation for Children's Health, 2010).

Type 2 diabetes is being more commonly diagnosed in children nationwide, whereas type 1 diabetes was the main form of diabetes that diagnosed in children about 25 years ago (Daniels, 2006.; (National Diabetes Information Clearinghouse [NDIC], 2007). A study in Kentucky demonstrates that the sharp increase in the amount of children diagnosed with type 2 diabetes is fueled by the conditions of poverty (Talbert, Wackerbarth, & Hattman, 2002). In this study, Medicaid records between 1994 and 2001 for people between the ages of 2 and 18 were analyzed. The analysis showed that the rate of diabetes incidence among the white population in the study was comparable to the rate of incidence for minority populations. Poverty related factors were a stronger driving force in type 2 diabetes prevalence in children than either genetics or ethnicity (Talbert, Wackerbarth, & Hattman, 2002).

Children in poverty are often subjected to stressful environments and, inadequate nutrition which affects physical and cognitive development (Lucile Packard Foundation for Children's Health, 2010). Also, these children do not have adequate access to health care, do not have access to quality education, and do not have as many opportunities for physical activity (Lucile Packard Foundation for Children's Health, 2010). All of these factors detract from the child's health and increase the risk of developing diabetes.

The focus of major research projects and resource allocation has also affected type 2 diabetes prevalence (Marsh, 2004). Research and resources are commonly focused on advertising as the major underlying cause of obesity and have not focused on the effect of poverty and deprivation on obesity (Marsh, 2004). Advertisements are designed to influence consumer choices. A focus on advertising suggests that obesity is viewed as an individual choice rather than a societal or community problem. Figure 10 shows the number of British articles that have been published about obesity and their focus (Marsh, 2004). Clearly, there was a much stronger focus on advertising than on poverty. Devoting more resources to study and rectify poverty's effect on obesity may help to alleviate the obesity epidemic.
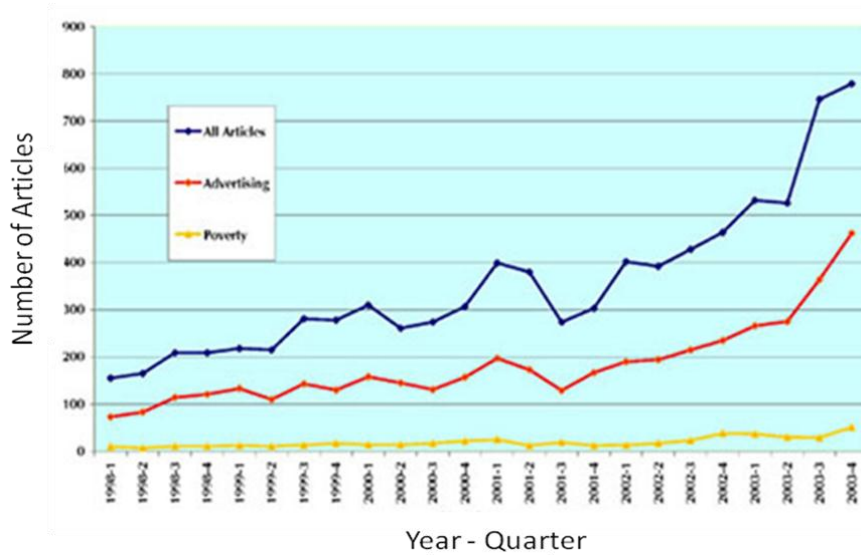
Figure 10. Articles published about poverty and advertising as risk factors for obesity (Marsh, 2004)

Also, many that are prediabetic, meaning that they have a high blood sugar content and are at risk for diabetes, are not aware of their condition and do not take preventative action to avoid developing diabetes (NDIC, 2007). In 2007 it was estimated that 57 million people in the united states that were prediabetic compared to the nearly 24 million who were diagnosed with diabetes at the time with an average of 1.6 million new cases of diabetes diagnosed each year (American Diabetes Association, 2010).

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DYNAMIC HYPOTHESIS

Exploring the dynamics behind the socio-economic discrepancies in diabetes prevalence demands that the social and environmental factors be included in the analysis; in this way, the broader picture is revealed. By seeing the whole picture instead of a piece of the puzzle, public health policies can be developed that include these factors and can become more effective (Kumanyika, Parker, and Sim, 2010). In this section, the information from the literature review will be used to create a dynamic hypothesis that explains the phenomenon of economic disparity with respect to diabetes. The hypothesis will be based on the dynamic relationships that are present between economic status and diabetes prevalence.   These relationships are explained using stock and flow diagrams and the underlying feedbacks and delays that are present. In these diagrams, feedback loops are designated as a balancing loop with a B and a reinforcing loop with an R. The arrows in the loops have either pluses or minuses next to them. A plus means that an increase (or decrease) in the first element will cause the second element to be higher (or lower) than it would have been otherwise, all other factors held constant.   A minus means that the two elements have an inverse relationship. This means that an increase (or decrease) in the first element will cause the second element to be lower (or higher) than it would have been otherwise, all other factors held constant.

Overview of the dynamic hypothesis

Current health policies focus on the individual behaviors that increase the risk of disease or facilitate disease progression (). While this is important because a person's self management skills are a strong combatant against disease, this approach does not consider the impact that social factors have on an individual's ability to manage a disease. An individual's self management capabilities are affected by the disease itself on both an emotional level and a financial level. In turn, a person's self management capacity influences his or her own emotional state creating reinforcing feedback. This feedback can be beneficial if a person is able to manage the disease well, but detrimental if the disease begins to overwhelm the person and damage the person's emotional state. The factors that influence the self management cycle need to be taken into consideration when developing policies and programs; otherwise they will continue to be ineffective.

Conventional health interventions: Focus on self-management of risk factors

As demonstrated in the literature review, the relationships between social factors and diabetes prevalence are complex. When a person is at risk of developing the type 2 diabetes, self management of the disease is extremely important. The person's attention to disease management can either reduce or increase the risk of developing the disease. The amount of risk factors in one's life determines the possibility of developing the disease. This represents a balancing feedback loop, where risk of the disease is kept at

bay through self management methods (diet control, exercise, etc). These relationships are outlined in Figure 11.
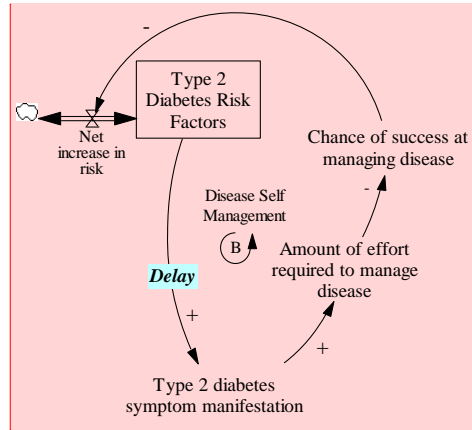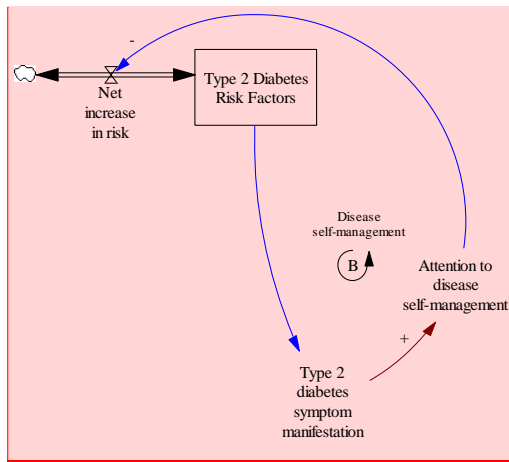

Figure 11. Disease self management

This loop is often the focus of health care policies and research. While it is one of the most crucial dynamics within the system because a person's individual success at managing the disease will greatly affect the rate at which the disease progresses, it is only a small piece of the puzzle.

Personal autonomy and the self management learning cycle

A person's ability to manage the disease can affect his or her sense of autonomy, which refers to a person's feelings of independence and power. If a person is able to manage the disease well, feelings of autonomy will increase; however, if the person struggles to manage the disease well, his or her feelings of autonomy may be challenged. The person's sense of autonomy will affect a person's drive and ability to solve problems. If a person feels in control of the situation, he or she may be more resilient in solving problems and will have a greater problem solving capacity; however, a low sense of autonomy can lead to depression and a sense of hopelessness which will lower a person's ability to solve problems. Problem solving skills will affect self management of diabetes. This dynamic is shown in loop R1 in Figure 12Figure 12.
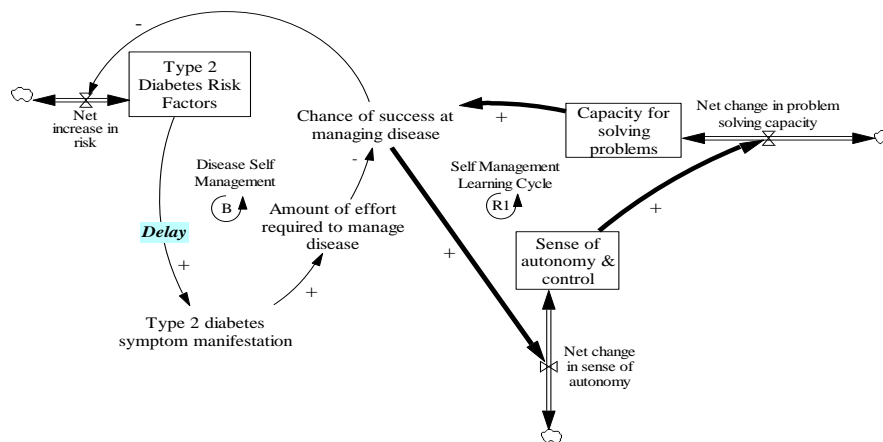
Figure 12. Self management learning cycle

The effects of a person's sense of autonomy are often overlooked or underestimated in policy development. The sense of autonomy fuels a person's problem solving efforts. If people feel that their efforts will make a difference in their situation, they will be motivated to continue and be diligent with their efforts. However, a low sense of autonomy will make people feel as if they are not as able to make an impact on their condition. Without taking this relationship into account, efforts to improve self management efforts will not be as effective.

Erosion of self management through disease progression

There are many elements that can affect a person's sense of autonomy with regard to disease progression. First of all, the manifestation of disease symptoms directly affects a person's sense of autonomy; however, there is a delay in this relationship. It takes time for the symptoms to progress to the point that the person feels overwhelmed and begins to lower his or her sense of autonomy. This dynamic is depicted in loop R2 of Figure 13.
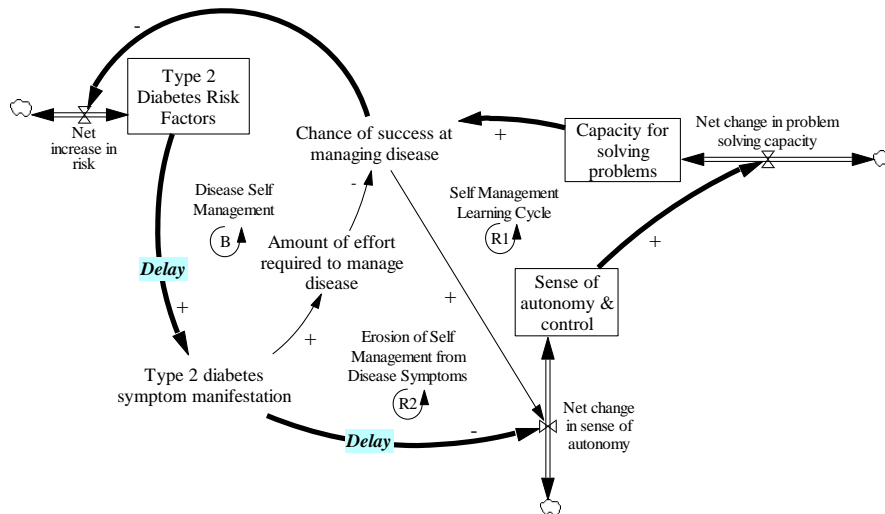
Figure 13. Erosion of self management from disease symptoms

As with most diseases, vigorous efforts in the early stages of the disease to slow its progression will result in easier management in the long run. Policy makers should take advantage of this delay to help people manage their diabetes before it gets out of hand so that their sense of autonomy is not damaged. When people find that they are able to keep their disease under control, they will be more motivated to continue their disease management efforts.

Comment [t17]: Policy makers should promote education?

Medical expenses and autonomy

Manifestation of diabetes symptoms will lead to more medical expenses. Medical expenses will detract from the net income, meaning that less money will be available for

other uses. This financial burden can lower one's sense of autonomy, which affects one's

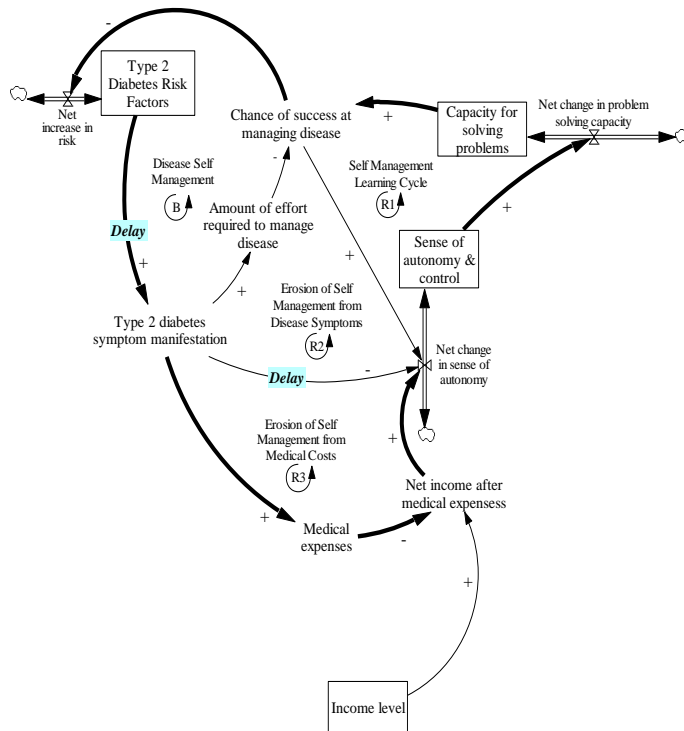self management abilities. This dynamic is explained in loop R3 in Figure 14.

Figure 14. Erosion of self management from medical costs

While there are some policies that help with medical expenses, people still have to

make payments with their own money either as deductibles, copaymentss, or for items

and procedures that are not covered.

Dynamics of physiological stress

A reduction in a person's amount of net income can increase physiological stress

levels as can the stress of having the disease itself. Increases in physiological stress leads

to weight gain. Being overweight can exacerbate current diabetic conditions. If the

disease progresses, physiological stress levels will increase; these relationships create a

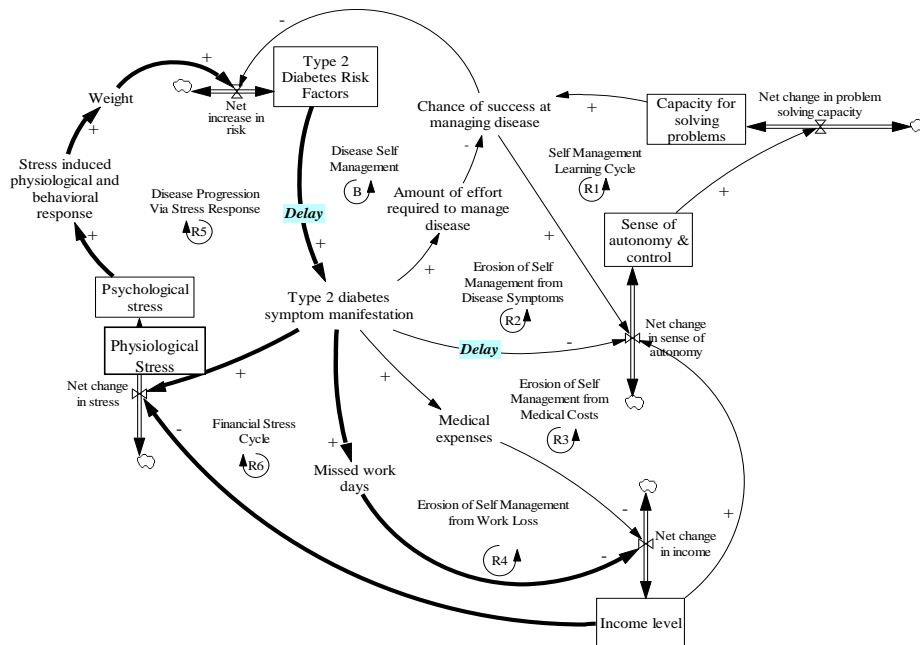reinforcing feedback loops and are depicted in loops R5 and R6 of Figure 15.

Figure 15. Physiological Stress

Education, autonomy, and self management

Self management is one of the most important elements in this dynamic system.

Effective policies will help to improve a person's self management capability. A

person's self management capabilities can be improved through education, though

educational progress is impacted by the person's sense of autonomy. The sense of

Comment [t18]: Include education here

autonomy affects a person's motivation, drive, and aspirations for educational progress. If a person has a strong sense of autonomy, educational progress is likely to continue to make educational progress. However, as the sense of autonomy erodes, the person's motivation and educational aspirations begin to fall. A person's education level affects the level of problem solving skills and the capacity to solve problems. Therefore, if education is improved, the person's problem solving capacity is improved and the person has a better chance of success at managing the disease. This dynamic is outlined in loop R7 of Figure 16.
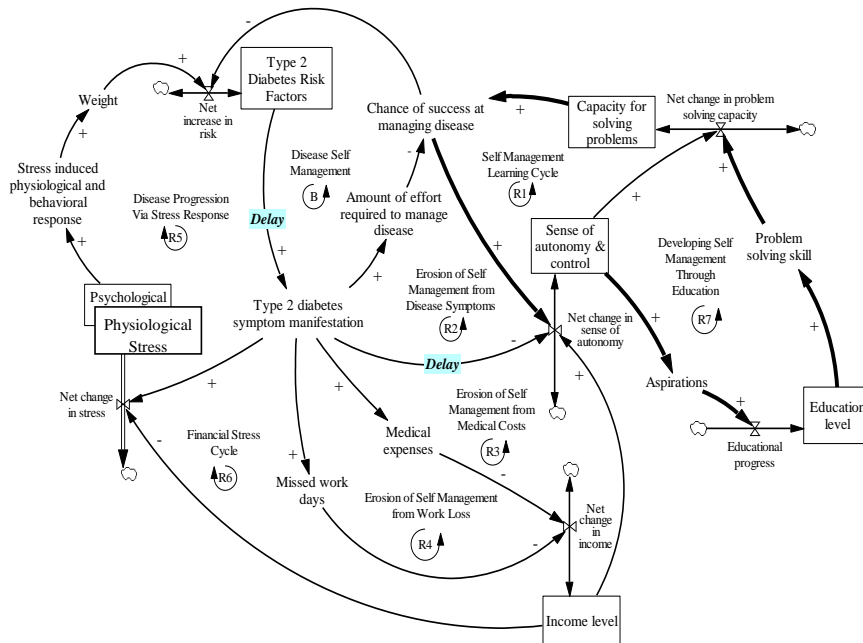
Figure 16. Developing self management through education

. Education is cumulative, meaning that once a person learns something valuable, he or she is able to build on this knowledge in the future. This is an important dynamic

for health care policymakers to consider. ~~Education is cumulative, meaning that once a person learns something valuable, he or she is able to build on this knowledge in the future.~~ Th~~is~~us ~~means that~~ knowledge gained during one stage in a person's life will enhance their capacity for learning at later stages in life and lead to greater educational progress over time. On the other hand, a failure to develop capabilities at one stage will cause the person to be at a disadvantage for learning in later stages in life, which will result in increasingly more inhibited learning progress in the future. The advantage of a cumulative effect within a community is the sharing of knowledge among community members.

Education, career, and autonomy

Education can also affect a person's career options. Higher levels of education ~~will~~ may mean better career options and more income (). A higher income level will help to increase a person's sense of autonomy as they are able to pay for their expenses. Increased autonomy will help to motivate people in their educational journey. This feedback is shown in loop R8 in Figure 17.
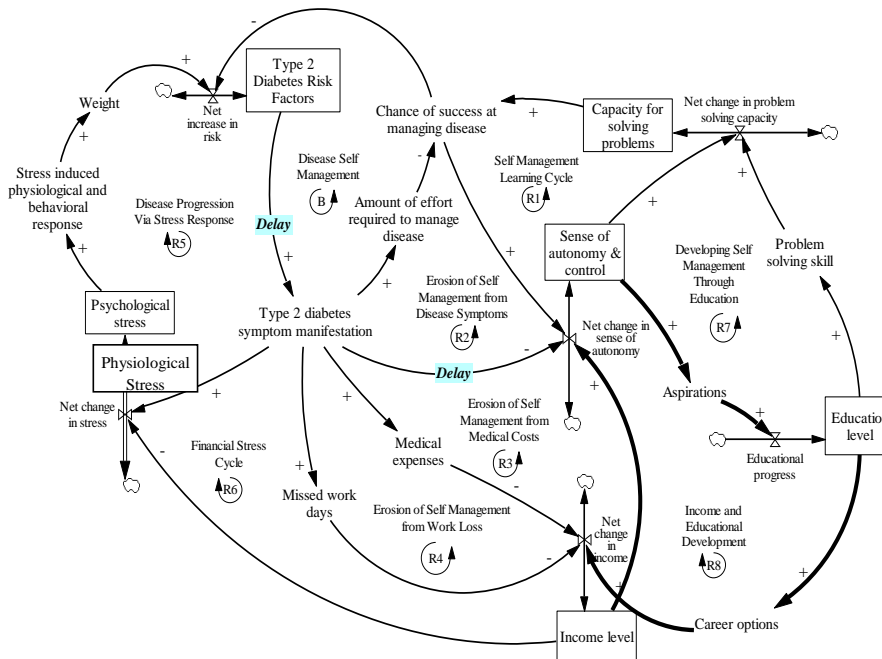
Figure 17. Income and educational development

Work environment and stress

The type of career influences the quality of the work environment. The quality of the work environment includes the working conditions and the freedom that the person has within the work place. If the quality of the work environment is poor, meaning that working conditions are hazardous or demanding and there is limited freedom in the workplace, the amount of job related stress increases. An increase in job related stress will in turn increase physiological stress and exacerbate disease progression though the physiological stress response. This dynamic is represented in loop R8 in Figure 18.

Policies that improve working conditions for low wage jobs, while not directly health
related, would work to improve the health of the workers.
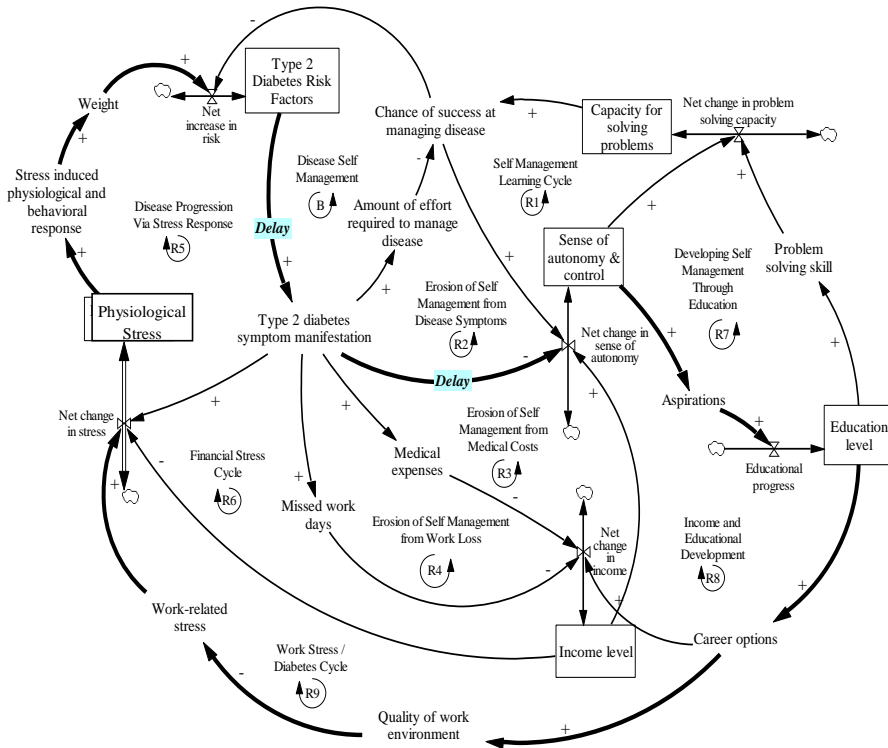
Figure 18. Work stress and diabetes

## Access to medical care and diabetes prevalence

Finally, access to health care can help to increase a person's success at managing
the disease, shown in Figure 19. Policy makers may focus on access to medical care, as it
works to improve a person's chances of success through direct medical intervention and
increasing a person's knowledge about self management strategies. By increasing a

Comment [t19]: What?

person's chance of success at disease management, people with the disease will have a better quality of life.

However, improved clinical management of diabetes through medical care is not a long term solution to diabetes prevalence (Jones et al., 2006). A study sponsored by the Division of Diabetes and Translation and the Division of Adult and Community Health at the CDC demonstrated that increases in disease management did reduce the rate of disease progression, but once the improvements reach a plateau, meaning that no new improvements are made, there is a rapid increase in the fatal complications associated with diabetes (Jones et al., 2006). This demonstrates the importance of integrating the long term effects into the policy making process in order to develop more robust policies.
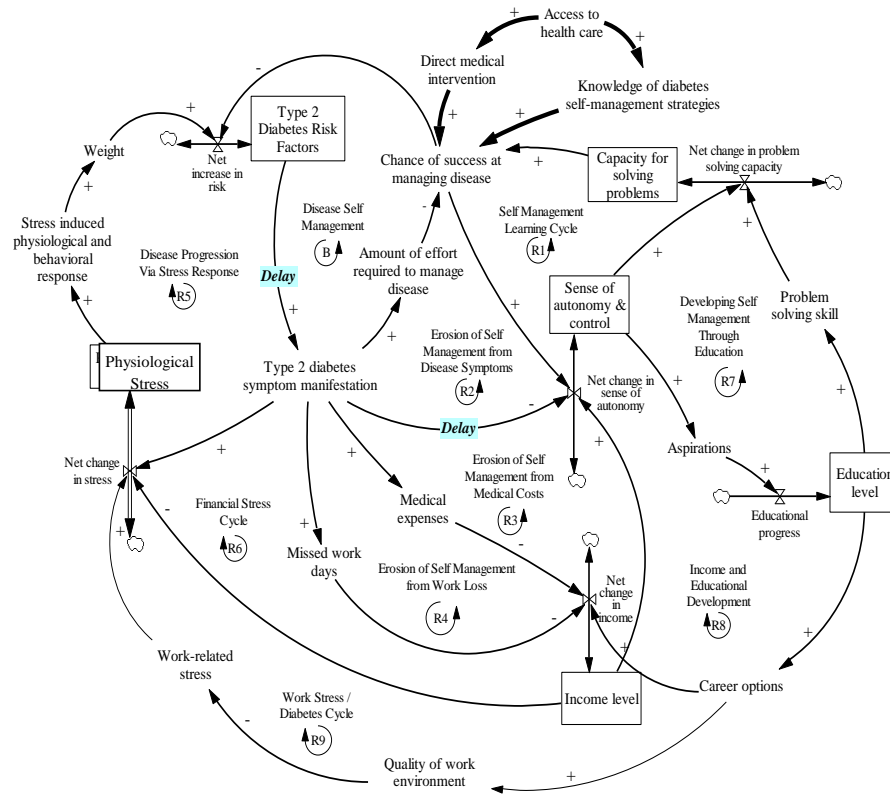
Figure 19. Access to health care

While it is important to note that policies that improve a person's access to health care will give the person a better chance of managing diabetes, the other factors that affect a person's chance of success cannot be ignored. Access to health care is often included in policy considerations, but the other elements that affect a person's chance of success are overlooked. Once all of the dynamics are analyzed, this information can be used during the policy making process and can lead to more successful policies.

<u>CONCLUSIONS</u>

The current medical research and healthcare policies focus on individual behaviors that place a person at risk of developing a disease and that will expedite disease progression. This is an important start to uncover risk factors and perhaps help to educate the public about which behaviors to avoid and which behaviors are healthy. Understandably, researchers must set limitations and boundaries for the study that they are performing, but they should account for the effects of social dynamics when designating these boundaries (Kumanyika, Parker, and Sim, 2010). A systems approach to health care policies can help to overcome current policy resistance, which occurs when the other interactions within the system are not accounted for in the policy (Kumanyika, Parker, and Sim, 2010). These other interactions in the system can counteract the policy or have a more dominant effect in the system than the policy which would make the policy changes futile.

Health care itself is only part of the battle in the fight against diabetes prevalence (Woolf, 2009). Social changes can serve as preventative measures to diabetes prevalence on an individual level and on a community level. For example, education can provide the knowledge and skills that individuals will need to make healthy choices (Woolf, 2009). On a community level, access to more supermarkets will provide healthier food options. Society must also embrace changes in order for them to be effective. For example, a positive community environment that encourages school participation will help facilitate any policy changes that affect education. While the social attitude is difficult to

incorporate into policies, including it in the policy making process may help to create more effective policies.

Social changes can improve health outcomes, but they must be accompanied by changes within the health care community including researchers, clinicians, and policy makers (Woolf, 2009). Policy makers should broaden their approach to consider all options and not focus only on clinical tools such as medications and diagnostic tests (Woolf, 2009). The most effective policies will involve both community improvements and health care improvements; in other words, they will involve multiple mechanisms within the dynamics of health care (Kumanyika, Parker, and Sim, 2010).

While eliminating poverty is not a feasible solution, policies that help to create alternative communities within communities in poverty may help to improve community health. It is difficult for individuals to start and maintain changes such as healthier dietary choices if the community around them continues with the same behaviors as before or lacks the ability to provide such choices. People want to feel that they are a part of a community, and behaving differently than the community will lead to feelings of isolation. The development of alternative communities within the larger community that provide a supportive environment for those who need to make behavioral changes can encourage members to participate in healthy behaviors and maintain their new lifestyle. Alternative community members can encourage other people in the community that need to make healthy changes in their lives to become a part of the support group. As more people become part of the alternative community and learn to keep healthier habits in their lives, the rate of diabetes incidence may be reduced which will lead to a reduction in diabetes prevalence.

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