THE PENNSYLVANIA STATE UNIVERSITY
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DEPARTMENT OF HEALTH POLICY AND ADMINISTRATION

COMORBID DIABETES AND DEPRESSION: THE RELATIONSHIP BETWEEN COMORBIDITY AND GLYCEMIC CONTROL

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ABSTRACT

This thesis will address the following research question: Do diabetics who are also diagnosed with depression have worse self-management of diabetes than diabetics who are not depressed? The hypothesis is that compared to non-depressed diabetics, persons who have diabetes and are also clinically depressed will be more likely to have uncontrolled diabetes (ADA, 2013).

The study uses data from the National Health and Nutritional Examination Survey (NHANES) collected in 2011 and 2012. Of the 5,740 people surveyed, an analytic sample of 608 adults had diabetes, and 98 also had clinical depression. Adults with diabetes and depression had an average HbA1c level of 7.84% mg/dL compared to 7.44% mg/dL for adults only with diabetes. The difference was not statistically significant, but given the small sample size, further study is warranted to determine whether diabetics also suffering from a major depressive disorder have worse self-management of their diabetes.

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Chapter 1

Introduction

In 2011, 25.8 million Americans had diabetes, and an additional 79 million had prediabetes (American Diabetes Association [ADA] 2014). Together, diabetes (8.3%) and prediabetes (35%) currently affect nearly 26 percent of the American population (ADA, 2014; CDC, 2011a). Type 2 diabetes accounts for 95% of all diabetic cases; it is preventable and treatable by living a healthy lifestyle such as eating a balanced diet and exercising regularly, and/or pharmacy (National Diabetes Education Program [NDEP], 2014).

The number of adults with diabetes has been on the rise and will continue to negatively affect the population's health over the next 50 years (Boyle et al., 2001). In fact, in the 15-year period between 1995 and 2010, age-adjusted prevalence rates for diabetes among U.S. adults increased from 4.5% to 8.2% (Centers for Disease Control and Prevention [CDC], 2012). The number of diabetics in the U.S. is expected to double by 2025 (ADA, 2014), in part because obesity rates and sedentary lifestyles have more than doubled in the last 25 years (Farag & Gaballa, 2010).

Complications and comorbid diseases associated with diabetes include heart disease, hypertension, renal disease, and nerve degeneration (NDEP, 2014). Diabetes is a major public health concern in the United States. The mortality rate of those diagnosed with diabetes is about twice that of individuals of the same age not diagnosed with diabetes; paired with heart disease, death rates among diabetics are four times that of non-diabetics (National Diabetes Information Clearinghouse [NDIC], 2014).

The effects and costs of diabetes are borne by all Americans. For example, people living with diabetes spend 2.3 times more in medical expenditures as those living without diabetes (ADA, 2014b). Diabetes care accounts for 1 in 5 health care dollars in the U.S. (ADA, 2014b). Research from American Diabetes Association in 2007 estimates the total direct and indirect cost for treating diabetes in the United States at $174 billion (NDIC, 2014). The ADA's latest 2012 research estimates the total cost of diagnosed diabetes has risen to $245 billion, representing a 41 percent increase in the last five years (ADA, 2014b). Costs indirectly attributed to diabetes include increased absenteeism, reduced productivity at work, reduced productivity for those not in the labor force, and lost productive capacity due to early mortality (ADA, 2014b).

Another common chronic condition among Americans is depression. At any time, ten percent of the U.S. adult population report having clinical depression (CDC, 2011b), and women are 70% more likely to experience clinical depression during their lifetime than men (NIMH, 2014a). Clinical depression is diagnosed when an individual suffers from a severely depressed mood for longer than a two-week period (NIMH, 2014b).

Depression typically cause emotional strain and interfere with daily life activities, such as school, work, sleeping, eating, and relationships with others (NIMH, 2014a). Caused by a combination of biological, environmental, genetic, and psychological factors, depression affects each individual differently with different signs and symptoms (NIMH, 2014a). Common signs and symptoms include feelings of pessimism or hopelessness, loss of interest in activities that were otherwise pleasurable, fatigue and decreased energy, difficulty concentrating or making decisions, insomnia, and poor dietary habits (NIMH, 2014a). Depending on the severity of the mental illness,

depression can adversely affect the clinical progression and outcomes of various chronic diseases, including diabetes (CDC, 2011b).

This thesis investigates the research question: Do diabetics who are also diagnosed with depression have worse self-management of diabetes than diabetics who are not depressed? Current literature recognizes a link between comorbid diabetes and depression; depression is more common among diabetics than in the overall population, and a bidirectional relationship has been hypothesized but not determined (Anderson, Freeland, Clouse, & Lustman, 2001; Carnethon, Kinder, Fair, Stafford, & Fortmann, 2003; Eaton, Armenian, Gallo, Pratt, & Ford, 1996). What is missing is research on whether comorbid depression and diabetes affects the patient's ability to self-manage his/her diabetes.

I hypothesize that adults who are clinically depressed will have less control of their diabetes than non-depressed adults. The clinical standard for controlled diabetes is having "glycemic control" (i.e. controlled blood sugar), which is measured by HbA_{1c} (ADA, 2013). The rationale behind the hypotheses is that adults who are clinically depressed are more likely to have diminished capacity (i.e. low energy, low motivation) to complete everyday tasks, especially if not effectively managed (National Institute of Mental Health [NIMH], 2014a). Depression can lead to substance abuse, an increased sedentary lifestyle, poor dietary habits, and diminished capacity to manage an individual's overall health (CDC, 2011b). Depressed individuals who have low energy and motivation may thus be less likely to engage in ongoing, health-related self-management behaviors to control their diabetes, such as exercising regularly, adhering to

healthy dietary changes, taking recommended medications, and checking one's blood sugar levels, all of which are known to help control diabetes (Eaton et al., 1996).

This study will make a new contribution to the literature by deepening our understanding of the relationship between depression and effective self-management of diabetes, which will continue to affect a large number of Americans. The findings may have implications for designing effective interventions to improve self-management of diabetes. If there are differences between depressed and non-depressed diabetics and in the control of diabetes, then part of effectively treating diabetes among the dually diagnosed may need to more explicitly incorporate mental health help, and vice versa. Patients with comorbid diabetes and depression may benefit from first treating depression, in order to increase the likelihood of them making major lifestyle changes required for effective the management of diabetes.

Chapter 2

Background and Conceptual Model

Comorbid Diabetes and Depression

Persons with diabetes have double the odds of being diagnosed with depression than persons who do not have diabetes (Anderson et al., 2001). The prevalence of depression was three to four times higher among patients with than the general population (Eaton et al., 1996). Comorbid diabetes and depression is difficult and expensive to control, and it is associated with increased diabetes complications, such as renal disease, impaired nerves, sexual dysfunction, and eye complications (Anderson et al., 2001). Lustman et al. (2000) found that diabetics with comorbid depression have a two-fold increased risk of mortality.

Conceptual model

Figure 1 presents the conceptual model for this study. Uncontrolled depression, or having a major depressive disorder, directly contributes to a decrease in the patient's motivation and energy to complete normal daily tasks, such as managing chronic illness (NIMH, 2014b).Proper diabetes management techniques include exercising, eating a healthy diet, smoking cessation, decreasing alcohol consumption, etc. (Simon, 2001). Depression has been known to inhibit exercise and the motivation to do so (CDC, 2011b). Major depressive disorders are associated with poorer dietary habits, including overeating and appetite loss (CDC, 2011b). Depression alone can have considerable negative health effects, but when combined with other chronic diseases, such as diabetes, it has been

associated with an even greater decrease in quality of life (Teh, Zaslavsky, Reynolds, & Cleary, 2010). Depressed individuals are less likely to maintain healthy exercise routines, stick to a healthy diet, and are more likely to engage in risky behaviors like smoking and drinking, which increase exacerbate the negative health effects associated with diabetes (CDC 2011b; Eaton et al., 1996).

Lastly, uncontrolled diabetes leads to a decline in a patient's health in both the short-run and the long-run. Such declines in health result in higher medical costs for the patient and higher direct and indirect costs nationwide to treat the diabetic population (ADA, 2014b).

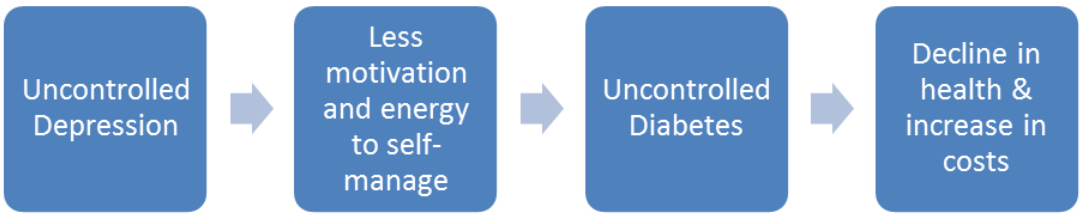

Figure 1. Conceptual model.

This study investigates the relationship between depression and diabetes. Specifically, it examines whether having comorbid depression and diabetes is related to control of diabetes. I hypothesize that:

H1: Among diabetics, clinical depression is positively associated with uncontrolled diabetes.

Chapter 3

Methods

Data

The data are from the National Health and Nutrition Examination Survey 2011-2012 (NHANES) database. The NHANES is a yearly, nationally representative survey of American adults and children, conducted by the National Center for Health Statistics (NCHS), which is part of the Centers for Disease Control and Prevention (CDC). It is a multi-stage survey of approximately 5,000 people across 15 counties in the United States (CDC, 2014). Each individual's overall health is assessed based on questionnaires, physical examinations, and laboratory tests administered by trained medical personnel (CDC, 2014). Since the publically available dataset I used is de-identified, analysis for this thesis was not subject to Institutional Review Board review.

This study utilized information from the Demographics Data, Questionnaire Data, and Laboratory Data of the NHANES 2011-2012. The data are collected and recorded at the individual-level. Demographic information included age in years, gender, race/ethnicity, and health insurance status. The Questionnaire Data provided diabetes and depression status, and the Laboratory Data included glycohemoglobin levels (CDC, 2014). Details of the questions asked, response choices, and response frequencies for each item can be found in Appendix B.

Sample

The full NHANES 2011-2012 dataset contains information from 5,740 individuals. The population of interest was diabetics. The analytic sample was

determined by an affirmative response to item DIQ010 (Appendix B) of the NHANES diabetes questionnaire: "Have you ever been told by a doctor or health professional that you have diabetes or sugar diabetes?" Only participants indicating "Yes" response were included in the analytic sample of 706 diabetic adults. Among diabetics, depression status was the exposure of interest.

The analytic sample was further decreased to 608 diabetic adults after eliminating 94 individuals who answered "Don't know" for all items of the Depression Screener Questionnaire, which is discussed later in this chapter. Ninety-eight members of the diabetic group and 331 members of the non-diabetic group met the CDC criteria for clinical depression by scoring 10 or higher on the DPQ index. The remaining 510 diabetics and 3897 non-diabetics scored less than 10 on the DPQ. A chi-square test for independence indicated a significant association between diabetes status and meeting the CDC criteria for depression ($p \leq 0.0001$), as summarized in Table 3. Among diabetic individuals, 16.12% scored over 10 on the depression score index, classifying them as having a major depressive disorder. In contrast, only 7.87% of the non-diabetic sample had symptoms of a major depressive disorder.

Table 1. Sample breakdown by depression score (Depression score >10 indicates clinical depression).

	Diabetic Individuals	Non-diabetic Individuals	Total
Meets clinical depression criteria*	98 (16.12%)	331 (7.87%)	429
Does not meet clinical depression criteria*	510 (83.88%)	3877 (92.13%)	4387
Total	608	4208	4816

*Indicates significance ($p \leq 0.0001$)

Analysis

Dependent Variable: Glycemic Control

Glycemic control is the dependent variable and is a standard measure of whether or not an individual's diabetes is under control. It indicates glycogenated hemoglobin, or sugar levels (HbA_{1c}), in the blood. According to the American Diabetes Association, patients with levels above 6.5% mg/dL are considered diabetic (ADA, 2014). For patients diagnosed with diabetes, proper glycemic control is demonstrated by having HbA_{1c} levels less than 7% mg/dL (ADA, 2014). A dichotomized variable was created for this study that classified diabetic patients into groups of HbA_{1c} levels either greater than or less than 7% mg/dL.

Exposure of Interest

The exposure of interest is a patient's depression status, obtained by the Depression Screener Questionnaire (DPQ), included in the NHANES dataset. The DPQ consists of ten questions and is a standard measure often used to assess a major depressive disorder (CDC, 2014).

The first nine items (Items DPQ010 to DPQ090 in Appendix B) use a 4-point likert scale to assess the frequency of depressive symptoms with the following response options: 0 = not at all, 1 = several days, 2 = more than half the days, and 3 = nearly every day. Patients responded to how they may have felt or behaved including: having little interest in doing things; feeling down, depressed, or hopeless; trouble sleeping or sleeping too much; feeling tired or having little energy; poor appetite or overeating; feeling bad about yourself; trouble concentrating on things; moving or speaking slowly or too fast; and thinking that you would be better off dead. For example, "Over the last 2

weeks, how often have you been bothered by the following problems: feeling down, depressed, or hopeless?"

A preliminary review indicated that no individuals refused to answer the questions, and 94 individuals responded with "Don't know" for all of the nine items. Therefore, these individuals were excluded the study, thereby reducing the analytic sample 608 diabetic adults.

A depression index was calculated using 9 items as a simple sum, as done in the literature (Pratt & Brody, 2008; CDC, 2014). The range is 0 to 27, and a score of 10 or higher has been validated and is recommended by the CDC to define depression (CDC, 2013; Pratt & Brody, 2008). In particular, the NHANES 2011-2012 DPQ items are similar questions to those in the Center for Epidemiologic Studies Short Depression Scale (CES-D 10), which has been widely-used in research and is regarded as an accurate assessment of an individual's level of depression. (Bjorgvinsson et al., 2013).

The tenth item of the NHANES depression questionnaire, DPQ100, asked a follow-up question to assess the overall daily issues caused by depressive symptoms: "How difficult have these problems made it for you to do your work, take care of things at home, or get along with people?" (Appendix B). The purpose of the index was to diagnose depression within the diabetic sample. Since the tenth question did not provide any new relevant information to diagnose major depression, it was excluded from the index. The reliability of the nine items was confirmed by a Cronbach's alpha coefficient of 0.86 for the overall sample. With the tenth item added into the index, the Cronbach's alpha coefficient was 0.84 (lower than when it was omitted), which validated our decision to exclude it from the depression index.

Controls

I controlled for an individual's age, gender, race/ethnicity and insurance status. Type 2 diabetes is much more prevalent in the adult population, age relates to illness severity, and it is also hypothesized to inhibit a person's ability to self-manage diabetes (Nolan, Damm, & Prentki, 2011). All individuals under age 18 were excluded from the continuous age variable, providing an age distribution of 18 to 80 years of age for the analytic sample. Since the prevalence of depression is higher in women and men (NIMH, 2014a), a dichotomous variable was included to control for gender differences. The prevalence of diabetes and depression are known to vary across racial and ethnic groups in the United States, due to socioeconomic status, the presence of other life-threatening diseases, absence of health insurance coverage, smoking rates, and exercise habits (Dunlop, Song, & Chang, 2003). Therefore, a categorical race/ethnicity variable (Appendix B) controlled for such differences, was kept ordinal, and had the following response options: 1 = Mexican American, 2 = Other Hispanic, 3 = Non-Hispanic White, 4 = Non-Hispanic Black, and 5 = Other Race, including Multi-Racial. Health insurance status is also a potential confounder, since it affects access to care, and the generosity of insurance affects diabetes care and one's ability to self-manage. Item HIQ011 from the NHANES 2011-2012 Health Insurance Questionnaire was used to classify each respondent as 1 = Yes or 2 = No for having health insurance (Appendix B).

Analysis Approach

This is a cross-sectional study that examines two groups of adult diabetics: diabetics who are clinically depressed and diabetics who are not depressed. Bivariate statistical analysis was used to determine the differences between the depressed diabetic

sub-sample (n=98) and the non-depressed diabetic sub-sample (n=510). Chi-square tests for independence examined the relationship between depression status and gender, race/ethnicity, and health insurance status. An independent t-test examined the relationship between depression status and age. Linear regression was employed to examine the relationship between the exposure of interest (depression) and the continuous glycohemoglobin variable, while controlling for socio-demographic co-variables. Logistic regression was used to examine the relationship between depression status and the dichotomous glycemic control variable, while again controlling for demographic factors. All analyses were conducted using SAS version 9.3.

Chapter 4

Results

NHANES Sample Characteristics:

The NHANES is supposed to be nationally representative of the demographics of the American population (CDC, 2014). This survey is used to assess national prevalence rates and incidence rates of diabetes and depression, making it a good dataset to examine those who are depressed and have comorbid depression (CDC, 2014). The NHANES sample used for this study is consistent with information known about the national U.S. population. Diabetes and depression prevalence rates in the analytic sample (n=608) for this study are consistent with the national rates, across the age, gender, and race demographic variables. As consistent with the literature, the prevalence of depression in this sample was higher among diabetics than non-diabetics (ADA, 2014c; Anderson et al., 2001; Carnethon et al., 2003; Eaton et al., 1996).

Analytic Sample

In order to examine the relationship that depression has on diabetes status, the diabetic sub-sample was broken down into two categories: depressed individuals and non-depressed individuals. Persons scoring a 10 or higher on the Depression Screener Questionnaire were classified as having a major depressive disorder, according to CDC guidelines. Patient characteristics for the depressed and non-depressed diabetic sub-samples have been summarized in Table 2. The mean age for clinically depressed diabetics was 57.23 years and 61.61 years for non-depressed diabetics. Though the mean

age of depressed diabetics was approximately four years younger than non-depressed individuals, chi-square tests for independence indicated that among diabetics only, there was no significant difference in ages between the two groups. There were, however, statistically significant differences in gender ($p \leq 0.0001$) and race ($p \leq 0.01$).

Table 2. Diabetic sample (n=608) by depression status.

	Depressed* (n=98)	**Non-depressed** (n=510)
Age	Mean: 57.2 SD: 13.4	Mean: 61.6 SD: 13.6
Gender**		
M	31.2%	52.63%
F	68.8%	47.37%
Race***		
Mexican American	10.1%	9.7%
Hispanic	18.4%	8.2%
White	34.9%	31.7%
Black	30.3%	36.7%
Other/Multi-Racial	6.4%	13.7%
Insured		
Yes	81.7%	86.2%
No	18.3%	13.8%

*Index score >10
**Indicates significance ($p \leq 0.0001$)
***Indicates significance ($p \leq 0.01$)

Depressed diabetics, on average, have higher HbA_{1C} levels than their non-depressed peers ($p \leq 0.01$). The mean glycohemoglobin level was 7.84% mg/dL for depressed diabetics and 7.44% mg/dL for non-depressed diabetics, as shown in Table 3.

Table 3. HbA1c differences between depressed and non-depressed diabetics.

	Depressed (n=90)	Non-Depressed (n=487)
HbA1C (mg/dL)*		
Mean:	7.84	7.44
SD:	2.30	1.83

*Indicates significance ($p \leq 0.01$)

Results from the linear regression model are displayed in Table 4. The bivariate analysis of depression status and a continuous measure of glycemic control was not significant (p=0.0685). For every one increase in years of age, there is a 0.0252 decrease in HbA_{1C} levels ($p \leq 0.001$). There was no statistically significant relationship found between depression status and gender, race, or insurance status.

Table 4. Linear regression for depression status and glycemic control.

Variable	Estimate	Standard Error	P-Value
Intercept*	8.9887	0.5606	<0.0001
No Depression	Reference	.	.
Depression	0.3323	0.2232	0.1372
Age*	-0.0252	0.0061	<0.0001
Females	Reference	.	.
Males	0.1728	0.1596	0.2793
Mexican American	0.2679	0.3396	0.4306
Other Hispanic	0.1535	0.3302	0.6422
White	-0.1781	0.2596	0.4928
Black	0.1995	0.2558	0.4358
Other (multi)	Reference	.	.
Insurance status	-0.1202	0.2343	0.6081

*Indicates significance ($p \leq 0.0001$)

Table 5 displays the results from a binary logistic regression model for depression status and a dichotomous glycemic control variable, where patients were classified as either having uncontrolled diabetes or having diabetes in control (HbA_{1c} levels above or below 7% mg/dL). The results indicated that comorbid diabetes and depression does not

increase the likelihood that diabetes will be uncontrolled (p=0.3924). As consistent with the previous linear regression model, age was significant (p≤0.01), but all other variables were not significant.

Table 5. Logistic regression for depression status and glycemic control.

Variable	Estimate	Standard Error	P-Value
Intercept	1.2985	0.6659	0.0512
Depression	0.0981	0.1147	0.3924
Age*	-0.0173	0.0064	0.0068
Gender	-0.1962	0.1671	0.2405
Race	-0.0287	0.0754	0.7036
Insurance status	0.0470	0.2438	0.8472

*Indicates significance (p<0.01)

Chapter 5

Discussion

Diabetes was more common among older people, the black racial/ethnic category, women, and those with health insurance. Each of these findings is consistent with literature concerning diabetes in the United States (ADA, 2014c; Anderson et al., 2001). There was a significant relationship between race and comorbid diabetes and depression ($p \leq 0.05$). Diabetic Mexican Americans, Hispanics, and Caucasians were more likely to be depressed than non-depressed members of the same race/ethic group. These results suggest that among diabetics, one's race may play a contributing factor to having comorbid depression. Reasoning behind racial and ethnic differences may be attributed to socioeconomic status, the presence of other life-threatening diseases, absence of health insurance coverage, smoking rates, and exercise habits; all of these factors vary across racial and ethnic groups in the United States (Dunlop, Song, & Chang, 2003).

It was hypothesized that diabetic individuals who experience symptoms of clinical depression would have higher rates of uncontrolled diabetes, as measured by higher HbA_{1c} levels, than diabetic individuals who are not clinically depressed. The results of this study showed that depressed diabetics did have higher HbA_{1c} levels than non-depressed diabetics, having a mean glycohemoglobin of 7.84% mg/dL versus 7.44% mg/dL. This suggests that depression does have an effect on a diabetic patient's ability to self-manage his/her diabetes; however, linear and logistic regression models did not indicate significance at $p \leq 0.05$ in the relationship between depression status and one's

control over managing diabetes. While the linear regression model for the bivariate of continuous glycemic control and depression status had a p-value of 0.06 and is not significant for $p \leq 0.05$, it met a 90% confidence standard ($p \leq 0.10$). The absence of significance may be due to a lack of statistical power, resulting from a small sample size. Because of the small sample size, I argue that further study is warranted, especially given the rising rates of diabetes in the United States. Establishing more clearly whether or not a relationship between diabetes and clinical depression exists is vital; there are important practical and clinical implications.

Both diabetes and comorbid depression can lead to a variety of complications, such as hypertension, cardiovascular disease, nerve impairment, sexual dysfunction, eye complications, and renal problems (Anderson et al., 2001; Lustman et al., 2000). The findings suggest that healthcare professionals managing diabetic patients should also screen for depression and treat mental health in addition to regulating glycemic control.

These findings are consistent across the literature. A meta-analysis of patients found that there is a robust association between depression and incidence of Type 2 diabetes (Eaton et al., 1996). Conversely, another study found that while there is a relationship between diabetes and depression, it is impossible to tell if the relationship between diabetes and depression is causal or coincidental (Talbot, 2000). It has been noted, however, that the first episode of major depressive disorder is recorded after the diagnosis of diabetes, leading to the belief that diabetes is a risk factor for depression. Additionally, the study completed by Talbot shows improved control over patient diabetes after depression remission is declared. Again, it is not possible to determine if this relationship causal or not (Talbot, 2000).

Limitations

There are several limitations with this study, all of which have to do with the study design. The first is that the data comes from a self-reported survey. It is likely that self-report recall bias has biggest influence on the depression scores (Disner, Beevers, Haigh, & Beck, 2004). Individuals may be likely to under report their feelings, particularly where mental health is concerned; depressed persons may over report their symptoms if they are highly distressed (Disner, Beevers, Haigh, & Beck, 2004). This would bias the results towards the hypothesis that there is a relationship between depression and diabetes. Future research regarding depression would benefit from a more comprehensive questionnaire to obtain better mental health data, including questions pertaining to diagnosis and management of a major depressive disorder. Instead of using self-reported depression information, actual diagnoses and physician reports would help to eliminate the self-report bias. In addition, since the direction of the diabetes/depression relationship cannot be determined from cross-sectional data, future research should be conducted using a longitudinal design to better understand how these two diseases are related.

Though the NHANES 2011-2012 dataset is highly regarded and used for a wide variety of studies, the sample size likely played a roll in the strength of the relationships found between the variables of interest. A larger sample, especially a larger sample of depressed diabetics, would increase the validity of the findings. It may be beneficial to design a study that specifically targets diabetic individuals and then examines the effects of depression within that sample.

There was also a considerable amount of missing data in the set, especially regarding the depression questionnaire. Ninety-eight diabetic patients were excluded from the study due to missing data or the inability to recall their depressive symptoms. Upon further review, there was no systematic reasoning for the missing responses; individuals spanned various ages, races, and both genders. Had the 98 individuals answered the questions, it likely would have increased the validity of the results.

With respect to the diabetes questionnaire, the questions did not assess whether individuals were actively trying to manage their disease. Questions pertaining to an individual's ability to gain control through weight loss, dietary changes, and exercise would be useful for future analysis. Due to this limitation, we cannot interpret whether or not diabetics who are depressed have made any attempts to control their diabetes with dietary changes or exercise.

Another well-known concern with studies is that we cannot determine causality: whether the outcome (depression) came before or after the exposure (diabetes). Thus, ideally, future research should use a longitudinal design to better understand how these two diseases are related.

Conclusion

In summary, adults with comorbid diabetes and depression had higher blood sugar levels than non-depressed diabetics, suggesting that they had less control of their diabetes. However, the differences between these two groups were not as drastic as hypothesized. This difference was statistically significant at $p \leq 0.01$, but after controlling for demographics, the relationship was no longer statistically significant ($p < 0.06$).

With the rates of diabetes increasing each year in the United States, continued research on this chronic disease is necessary to public health and for efforts to combat the rising prevalence. Given the sample size for this study and the increasing rates of diabetes and depression, future research is needed to advance our understanding of the nature of the relationship between these two chronic conditions. Mental health affects physical health and indeed does play a role in diabetes management; however, we cannot interpret the effects of depression and compare them to other diabetes self-management techniques, like proper nutrition, leading an active lifestyle with plenty of exercise, and medication treatment.

Appendix A

SAS Code

Dataset modification and examining characteristics:

VARIABLE SELECTION AND MERGING SETS:

```
libname clg "V:\My Documents\Thesis\Data Files";
run;

data demographics;
set clg.demo_g;
run;

data laboratory;
set clg.ghb_g;
run;

data questionnaire;
set clg.dpq_g;
run;

data diabetes;
set clg.diq_g;
run;

data insurance;
set clg.hiq_g;
run;

data demo1;
set demographics;
keep seqn riagendr ridageyr ridreth1;
run;

data lab1;
set laboratory;
keep seqn lbxgh;
run;

data diab1;
set diabetes;
keep seqn diq010;
run;

data insure;
set insurance;
keep seqn hiq011;
```

```
run;

*Sort by ID before merging;
proc sort data=demo1;
by seqn;
run;

proc sort data=lab1;
by seqn;
run;

proc sort data=questionnaire;
by seqn;
run;

proc sort data=diab1;
by seqn;
run;

proc sort data=insure;
by seqn;
run;

data merged;
merge demo1 lab1 questionnaire diab1 insure;
by seqn;
run;

proc contents data=merged;
run;

data subset; set merged;
```

FOR DIABETIC AND NON-DIABETIC SAMPLES

```
libname clg "E:\Data Files\Chris";

data clg.describe; set clg.subset


;****Dropping "Refused", "Don't know", and "missing***;
if dpq010 ge 5 then dpq010 =.;
if dpq020 ge 5 then dpq020 =.;
if dpq030 ge 5 then dpq030 =.;
if dpq040 ge 5 then dpq040 =.;
if dpq050 ge 5 then dpq050 =.;
if dpq060 ge 5 then dpq060 =.;
if dpq070 ge 5 then dpq070 =.;
if dpq080 ge 5 then dpq080 =.;
if dpq090 ge 5 then dpq090 =.;
if dpq100 ge 5 then dpq100 =.;

*Greater than 7=uncontrolled;
```

```
if lbxgh ge 7 then gcontrol =0;
if lbxgh lt 7 then gcontrol =1;

*1=yes & 2=no for diabetes;
if diq010 eq 1 then diabetes =1;
if diq010 eq 2 then diabetes =0;
*for the diabetic-only sample, dropping all values of 0;
*if diabetes=0 then delete;

*creating depression index;
depression=dpq010+dpq020+dpq030+dpq040+dpq050+dpq060+dpq070+dpq08
0+dpq090;
if depression lt 10 then depstatus =0;
if depression ge 10 then depstatus =1;
if depression=. then delete;

if depression lt 10 then depthree =0;
if depression ge 10 and depression le 15 then depthree =1;
if depression gt 15 then depthree =2;
if depression=. then delete;
if hiq011 eq 1 then insure=1;
if hiq011 eq 2 then insure=2;
if hiq011 ge 3 then insure=.;

if ridageyr ge 18;
run;


proc sort; by depstatus;run;
proc sort; by diabetes;run;

proc freq; tables insure*diabetes; run;

proc freq; tables depstatus*diabetes/chisq; run;

proc freq; tables depthree*diabetes/chisq; run;

proc freq; tables depstatus*(riagendr ridreth1 insure)/chisq;
run;



***Independent t-tests;
*diabetes and age;
proc ttest;
class diabetes;
var ridageyr;
run;

* depression status and age;
proc ttest;
class depstatus;
var ridageyr;
run
```

```
*diabetes and glycohemoglobin;
proc ttest;
class diabetes;
var lbxgh;
run;
```

FOR DIABETES SAMPLE ONLY

```
libname clg "E:\Data Files\Chris";

data clg.dmonly; set clg.subset


;****Dropping "Refused", "Don't know", and "missing***;
if dpq010 ge 5 then dpq010 =.;
if dpq020 ge 5 then dpq020 =.;
if dpq030 ge 5 then dpq030 =.;
if dpq040 ge 5 then dpq040 =.;
if dpq050 ge 5 then dpq050 =.;
if dpq060 ge 5 then dpq060 =.;
if dpq070 ge 5 then dpq070 =.;
if dpq080 ge 5 then dpq080 =.;
if dpq090 ge 5 then dpq090 =.;
if dpq100 ge 5 then dpq100 =.;

*Greater than 7=uncontrolled;
if lbxgh ge 7 then gcontrol =0;
if lbxgh lt 7 then gcontrol =1;

*1=yes & 2=no for diabetes;
if diq010 eq 1 then diabetes =1;
if diq010 eq 2 then diabetes =0;

*creating depression index;
depression=dpq010+dpq020+dpq030+dpq040+dpq050+dpq060+dpq070+dpq08
0+dpq090;
if depression lt 10 then depstatus =0;
if depression ge 10 then depstatus =1;
if depression=. then delete;

if depression lt 10 then depthree =0;
if depression ge 10 and depression le 15 then depthree =1;
if depression gt 15 then depthree =2;
if depression=. then delete;
if hiq011 eq 1 then insure=1;
if hiq011 eq 2 then insure=2;
if hiq011 ge 3 then insure=.;

if ridageyr ge 18;
if diabetes eq 1;
run;
******Independent t-tests;
```

```
*diabetes and age;
proc ttest;
class depstatus;
var lbxgh;
run;

proc ttest;
class depstatus;
var lbxgh;
run;

**linear regression on diabetes & depression;
proc glm;
class depstatus;
model lbxgh = depstatus/ solution;
run;

**With potential confounders;
proc glm;
class depstatus riagendr ridreth1;
model lbxgh = depstatus ridageyr riagendr ridreth1 insure/
solution;
run;

**Logistic regression;
proc logistic;
class depstatus;
model gcontrol=depstatus ridageyr riagendr ridreth1 insure;
run;
```

Appendix B

NHANES Variables

DIQ010 - Doctor told you have diabetes
Variable Name: DIQ010
SAS Label: Doctor told you have diabetes
English Text: The next questions are about specific medical conditions. {Other than during pregnancy, {have you/has SP}/{Have you/Has SP}} ever been told by a doctor or health professional that {you have/{he/she/SP} has} diabetes or sugar diabetes?
English Instructions: CAPI INSTRUCTION: IF SP AGE < 15, DISPLAY "HAVE SP" FOR THE FIRST DISPLAY AND "SP HAS" FOR THE SECOND DISPLAY. IF SP IS FEMALE AND AGE >= 20, DISPLAY "OTHER THAN DURING PREGNANCY, {HAVE YOU/HAS SP}".
Target: Both males and females 1 YEARS - 150 YEARS

Code or Value	Value Description	Count	Cumulative	Skip to Item
1	Yes	708	708	
2	No	8524	9232	DIQ159
3	Borderline	125	9357	DIQ159
7	Refused	1	9358	DIQ159
9	Don't know	5	9363	DIQ159
.	Missing			

DPQ010 - Have little interest in doing things
Variable Name: DPQ010
SAS Label: Have little interest in doing things
English Text: Over the last 2 weeks, how often have you been bothered by the following problems: little interest or pleasure in doing things? Would you say...
English Instructions: HANDCARD DPQ1
Target: Both males and females 18 YEARS - 150 YEARS

Code or Value	Value Description	Count	Cumulative
0	Not at all	3726	3726
1	Several days	800	4526
2	More than half the days	214	4740
3	Nearly every day	201	4941
7	Refused	2	4943
9	Don't know	8	4951
.	Missing	664	5615

DPQ020 - Feeling down, depressed, or hopeless
Variable Name: DPQ020
SAS Label: Feeling down, depressed, or hopeless
English Text: [Over the last 2 weeks, how often have you been bothered by the following problems:] feeling down, depressed, or hopeless?
English Instructions: HANDCARD DPQ1
Target: Both males and females 18 YEARS - 150 YEARS

Code or Value	Value Description	Count	Cumulative
0	Not at all	3763	3763
1	Several days	817	4580
2	More than half the days	190	4770
3	Nearly every day	174	4944
7	Refused	1	4945
9	Don't know	4	4949
.	Missing	666	5615

DPQ030 - Trouble sleeping or sleeping too much
Variable Name: DPQ030
SAS Label: Trouble sleeping or sleeping too much
English Text:[Over the last 2 weeks, how often have you been bothered by the following problems:] trouble falling or staying asleep, or sleeping too much?
English Instructions: HANDCARD DPQ1
Target: Both males and females 18 YEARS - 150 YEARS

Code or Value	Value Description	Count	Cumulative
0	Not at all	3127	3127
1	Several days	1068	4195
2	More than half the days	319	4514
3	Nearly every day	429	4943
7	Refused	1	4944
9	Don't know	4	4948
.	Missing	667	5615

DPQ040 - Feeling tired or having little energy
Variable Name: DPQ040
SAS Label: Feeling tired or having little energy
English Text: [Over the last 2 weeks, how often have you been bothered by the following problems:] feeling tired or having little energy?
English Instructions: HANDCARD DPQ1
Target: Both males and females 18 YEARS - 150 YEARS

Code or Value	Value Description	Count	Cumulative
0	Not at all	2624	2624
1	Several days	1548	4172
2	More than half the days	372	4544
3	Nearly every day	400	4944
7	Refused	1	4945
9	Don't know	2	4947
.	Missing	668	5615

DPQ050 - Poor appetite or overeating
Variable Name: DPQ050
SAS Label: Poor appetite or overeating
English Text: [Over the last 2 weeks, how often have you been bothered by the following:] poor appetite or overeating?
English Instructions: HANDCARD DPQ1
Target: Both males and females 18 YEARS - 150 YEARS

Code or Value	Value Description	Count	Cumulative
0	Not at all	3757	3757
1	Several days	732	4489
2	More than half the days	219	4708
3	Nearly every day	235	4943
7	Refused	1	4944
9	Don't know	3	4947
.	Missing	668	5615

DPQ060 - Feeling bad about yourself
Variable Name: DPQ060
SAS Label: Feeling bad about yourself
English Text: [Over the last 2 weeks, how often have you been bothered by the following problems:] feeling bad about yourself - or that you are a failure or have let yourself or your family down?
English Instructions: HANDCARD DPQ1
Target: Both males and females 18 YEARS - 150 YEARS

Code or Value	Value Description	Count	Cumulative
0	Not at all	4080	4080
1	Several days	555	4635
2	More than half the days	149	4784
3	Nearly every day	154	4938
7	Refused	2	4940
9	Don't know	6	4946
.	Missing	669	5615

DPQ070 - Trouble concentrating on things
Variable Name: DPQ070
SAS Label: Trouble concentrating on things
English Text: [Over the last 2 weeks, how often have you been bothered by the following problems:] trouble concentrating on things, such as reading the newspaper or watching TV?
English Instructions: HANDCARD DPQ1
Target: Both males and females 18 YEARS - 150 YEARS

Code or Value	Value Description	Count	Cumulative
0	Not at all	4142	4142
1	Several days	495	4637
2	More than half the days	146	4783
3	Nearly every day	159	4942
7	Refused	1	4943
9	Don't know	3	4946
.	Missing	669	5615

DPQ080 - Moving or speaking slowly or too fast
Variable Name: DPQ080
SAS Label: Moving or speaking slowly or too fast
English Text: [Over the last 2 weeks, how often have you been bothered by the following problems:] moving or speaking so slowly that other people could have noticed? Or the opposite - being so fidgety or restless that you have been moving around a lot more than usual?
English Instructions: HANDCARD DPQ1
Target: Both males and females 18 YEARS - 150 YEARS

Code or Value	Value Description	Count	Cumulative
0	Not at all	4393	4393
1	Several days	331	4724
2	More than half the days	94	4818
3	Nearly every day	122	4940
7	Refused	1	4941
9	Don't know	4	4945
.	Missing	670	5615

DPQ090 - Thought you would be better off dead
Variable Name: DPQ090
SAS Label: Thought you would be better off dead
English Text: Over the last 2 weeks, how often have you been bothered by the following problems: Thoughts that you would be better off dead or of hurting yourself in some way?
English Instructions: HAND CARD DPQ1
Target: Both males and females 18 YEARS - 150 YEARS

Code or Value	Value Description	Count	Cumulative
0	Not at all	4747	4747
1	Several days	124	4871
2	More than half the days	33	4904
3	Nearly every day	36	4940
7	Refused	2	4942
9	Don't know	2	4944
.	Missing	671	5615

Variable Name: DPQ100
SAS Label: Difficulty these problems have caused
English Text: How difficult have these problems made it for you to do your work, take care of things at home, or get along with people?
Target: Both males and females 18 YEARS - 150 YEARS

Code or Value	Value Description	Count	Cumulative
0	Not at all difficult	2262	2262
1	Somewhat difficult	739	3001
2	Very difficult	130	3131
3	Extremely difficult	63	3194
7	Refused	0	3194
9	Don’t know	5	3199
.	Missing	2416	5615

RIDRETH1 - Race/Hispanic origin
Variable Name: RIDRETH1
SAS Label: Race/Hispanic origin
English Text: Recode of reported race and Hispanic origin information
Target: Both males and females 0 YEARS - 150 YEARS

Code or Value	Value Description	Count	Cumulative
1	Mexican American	1355	1355
2	Other Hispanic	1076	2431
3	Non-Hispanic White	2973	5404
4	Non-Hispanic Black	2683	8087
5	Other Race - Including Multi-Racial	1669	9756
.	Missing	0	9756

HIQ011 - Covered by health insurance
Variable Name: HIQ011
SAS Label: Covered by health insurance
English Text: The (first/next) questions are about health insurance. {Are you/Is SP} covered by health insurance or some other kind of health care plan? [Include health insurance obtained through employment or purchased directly as well as government programs like Medicare and Medicaid that provide medical care or help pay medical bills.]
Target: Both males and females 0 YEARS - 150 YEARS

Code or Value	Value Description	Count	Cumulative
1	Yes	8033	8033
2	No	1703	9736
7	Refused	4	9740
9	Don't know	16	9756
.	Missing		

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ACADEMIC VITA

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Education

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Honors and Awards

Schreyer Honors College
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Professional Experience

The Pennsylvania State University
Research Assistant, Center for Health Care and Policy Research — University Park, PA — 5/11 – Present

- Compile qualitative data into user-friendly forms.
- Enter codes into Atlas.ti software database.
- Trained and oriented two new undergraduate/graduate students to the project.
- Developed a codebook for site visit interviews in 2011.

Geisinger Health System
Administrative Intern, Community Practice Service Line – Western Region — Port Matilda, PA — 5/13 – 8/13

- Researched employee incentive programs in order to re-design the current system.
- Developed organizational charts for Community Practice and all medical specialties in Geisinger's Western Region.
- Surveyed the Region for pediatric therapeutic resources, and compiled information to be used in a business plan for a pediatric special needs clinic.

Leadership

Schreyer Honors College Student Council — 2010 - 2014
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