HOW DO SOCIODEMOGRAPHICS, PERCEIVED BARRIERS, AND PHYSICAL CHALLENGES AFFECT BLOOD GLUCOSE MONITORING AMONG PEOPLE WITH TYPE 2 DIABETES?

by

Jacob Marvin, MS, CPH, a-IPC

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Signature:

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Jacob Marvin, Student Date

Approvals:

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Dr. Nicolette Powe, Dissertation Advisor Date

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Dr. Ken Learman, Committee Member Date

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Dr. Andy Chang, Committee Member Date

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Dr. Salvatore A. Sanders, Dean of Graduate Studies Date

ABSTRACT

Background: Lifestyle modifications have been at the forefront of maintaining proper glycemic control; however, adherence to blood glucose monitoring remains a vital strategy in controlling diabetes. This dissertation investigates and details how sociodemographics, perceived barriers and physical challenges affect blood glucose monitoring for those that are suffering from Type II diabetes.

Methods: This research examines the perceived barriers and challenges that may exist that inhibit one's ability to properly monitor their blood glucose levels through a cross-sectional study using the 2013-2020 (Pre-Pandemic) NHANES data cycles/sets for the United States population.

Results: In the 18-39 age bracket, these results show that sociodemographics, specifically duration of illness with or without gender was significant, irrespective of race/ethnicity. In the 40-60 age group: gender, duration of illness, were the sociodemographics that showed to have a significant association to blood glucose monitoring. Finally, the 61+ age category had no sociodemographic variables of significant consequence, factoring in or out race/ethnicity. However, this study found all adults 18+ had an association with prescription coverage, occupational status, race, gender, and age. All of these variables played a significant role in affecting diabetes blood glucose monitoring.

Conclusions: This research affirms that there are numerous external and non-modifiable factors that contribute to the diabetes blood glucose monitoring adherence.

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PREFACE

Acknowledgements

There are so many people that I would like to thank that helped me along my educational journey. First, my grandparents: Sue, Lanny, and Harold. Grandma Sue and Grandpa Lanny: without you, it would not have been possible for me to have gone this far in school. Grandpa Harold: Even though you have passed, I know you are looking down, smiling that I made it this far. I really do wish you could be here to witness all of this. Next, my mom, dad, and sister: Heather, Tom, and Laney. Mom: Thank you for always knowing I could do it and pushing me to be the absolute best I could be. Dad: Thank you for always reading my papers, even the night before they were due, and always pushing me to be a man and a better person. Laney: Thank you for all the encouragement.

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Thank you all so very much!

IRB

Feb 28, 2022 11:01:04 AM EST

Re: Exempt - Initial - 2022-131 HOW DO SOCIODEMOGRAPHICS, PERCEIVED BARRIERS, AND PHYSICAL CHALLENGES AFFECT BLOOD GLUCOSE MONITORING AMONG PEOPLE WITH TYPE 2 DIABETES?

Youngstown State University Human Subjects Review Board has rendered the decision below for HOW DO SOCIODEMOGRAPHICS, PERCEIVED BARRIERS, AND PHYSICAL CHALLENGES AFFECT BLOOD GLUCOSE MONITORING AMONG PEOPLE WITH TYPE 2 DIABETES?

Decision: Exempt.

Findings: Researchers are using pre-existing data set Pre-Pandemic 2017-2020 NHANES. This is available to anyone on the internet. Approved.

Chapter 1

Disparities in Diabetes Based on Sociodemographics

Diabetes Mellitus is a growing health issue in the United States, with 37.3 million individuals (11.3%) currently living with diabetes, including 35.4 million having Type 2 Diabetes.[1,2] Efforts to prevent and control diabetes, are supported through self-management practices focused on lifestyle modifications for the maintenance of proper glycemic control.[3] Although, there are numerous preventive and sustaining measures for diabetes, one prevailing measure is blood glucose monitoring. However, perceived barriers, sociodemographics and physical challenges can prohibit or limit the compliance to blood glucose monitoring. Further, there is a severe lack of data and literature surrounding potential barriers to diabetes self-management practices and prevention. This research aims to identify and evaluate blood glucose monitoring barriers among those living with Type 2 Diabetes. This chapter will provide an overall introduction to the study and background to diabetes self-management practices and potential barriers/challenges that may exist.

Importance of Blood Glucose Monitoring Among Type 2 Diabetes

Advanced preventive and mitigation strategies have increased blood glucose monitoring knowledge and maintenance measures. Blood glucose monitoring is where an individual checks the amount of sugar (glucose) in their blood. There are numerous factors that can alter blood sugar levels: weight, diet, diabetes medication, exercise, certain illnesses, and stress levels.[4] Ideally, these levels should be checked at least four times a day; however, that is pending insulin-dependence and one's respective healthcare-team's recommendation.[5] Despite this guidance, many individuals do not adhere to this diabetes self-management tactic. A large question remains, what factors contribute to this non-compliance?

Diabetes Barriers and Physical Challenges

This research will assess the role of sociodemographics in adherence to diabetes self-monitoring; while, examining the perceived barriers and challenges that may exist that inhibit one's ability to properly monitor their blood glucose levels. Although, there are several diabetes-related complications possible, it is important to acknowledge pre-existing comorbities or disabilities. Given the largest diabetes at-risk population being the elderly population, it is imperative that cognitive status and disability status be accounted for in preparing a diabetes self-care plan formulated from health education specialists.[6] Moreover, documenting physical impairments is a necessary step, as with the elderly and disabled populations, it can be challenging to hold the blood glycosometer or if there is a cognitive challenge is can be very difficult for individuals to retain or replicate shown diabetes self-management strategies, such as blood glucose monitoring.[6]

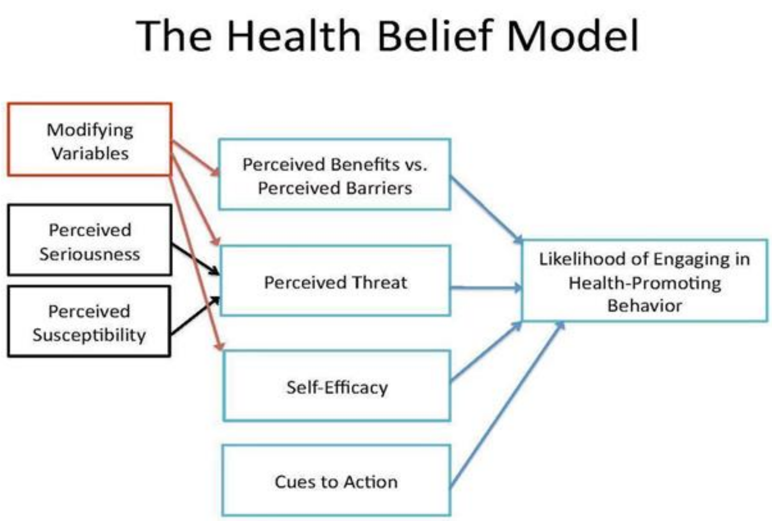
Prior Research Targeting Type 2 Diabetes Blood Glucose Monitoring

This study shows significant importance as this study and previous accompanying studies, would show the progression of diabetes monitoring from 2013 through March 2020 and to potentially see the increase, decrease, or relative consistency of rates. Furthermore, this study may be helpful in showing strong contributing factors for increases in Type 2 Diabetes rates in the US, pre-SARS-CoV-2 pandemic. Finally, this study will show the relationships and potential barriers or challenges that exist, leading to a separation in adherence to diabetes self-management practices.

Theoretical Framework to Diabetes Adherence to Blood Glucose Monitoring

The assessment analysis for this dissertation project models the Health Belief Model (HBM) which explains and predicts individual changes in health behaviors. As an individual's perceived threat to diabetes (perceived susceptibility), belief of consequence (perceived severity), potential positive benefits of action (perceived benefits), perceived barriers to action, exposure to factors that prompt action (cues to action), and confidence in ability to succeed (self-efficacy) are associated with the greater likelihood of engaging in health-promoting behaviors.[7,8]

Figure 1. Theoretical Model to Assess Diabetes Adherence of Blood Glucose Monitoring



In previous studies, women reported having better diet and self-monitoring blood glucose behaviors; but higher BMIs, higher blood pressure and higher Alc, when compared to men due to psychosocial factors: more depressive symptoms and weaker perception of familial support.[9] Moreover, Ruggiero et al. reported there is a separation across age categories (18-44, 45-54, 55-64, 65+) in diabetes self-management practices, where dieting, medication adherence, and blood glucose monitoring increased with age.[10] The aforementioned research describes how individual demographics and adherence to blood glucose monitoring have been studied. However, previous research has not collectively addressed demographics, such as: age, gender, duration of illness, and the adherence to blood glucose monitoring.

The HBM has been applied to comprehend adherence to diabetes self-management practices as it relates to regimen compliance, and it was found that the HBM was useful for explaining noncompliance and designing compliance-enhancing interventions.[11]

Individuals that are uninsured with diabetes are less likely to seek medical advice, have hemoglobin A1c tests, or to perform daily blood glucose monitoring than those with private health insurance.[12] Additionally, research has indicated that patients with diabetes experience elevated levels of diabetes-specific emotional stress which associates with functional impairment, poor adherence to exercise, diet and medications, and inadequate glycemic control.[13]

Purpose of the Dissertation

The purpose of this dissertation is to assess variables that individuals may be born-with or non-modifiable, yet still affect their adherence to diabetes blood glucose monitoring. In Chapter 2, this research addresses sociodemographic variables that an individual may possess and have no control over (aging, time, etc.), but that may be affecting their diabetes self-management, specifically blood glucose monitoring. Furthermore, the research in Chapter 3 assesses physical challenges and how that may be affecting the blood glucose monitoring and/or diabetes self-management. Finally, in Chapter 4, this chapter describes the financial or occupational issues that may be inhibiting proper blood glucose monitoring and overall diabetes self-management.

Specific Aim 1: Individual demographic characteristics and adherence to self-management practices have been studied; however, further research is necessary to comprehend this complex relationship among age, gender, and self-monitoring of blood glucose levels adherence.[14] Furthermore, the relationship between the duration of Type 2 Diabetes and the adherence to blood glucose monitoring has not been adequately studied.[14] This study examines sociodemographic differences in adherence to blood glucose monitoring by gender, age, and duration of illness from the NHANES datasets.

Research Question 1: What is the relationship between sociodemographics and adherence to blood glucose monitoring?

Research Hypothesis 1: Older adults (61+) will have better blood glucose monitoring adherence compared to young adults (18-39) or middle-aged adults (40-60).

Specific Aim 2: Previous studies have not investigated the use of the Health Belief Model (HBM) to a nationally representative dataset in an attempt to examine the relationship between individuals with diabetes' perceived health status, perceived health benefit, and blood glucose monitoring. This study looked to examine perceived health status and perceived disability status in adherence to blood glucose monitoring from the NHANES datasets.

Research Question 2: What is the relationship of perceived barriers and adherence to blood glucose monitoring (outcome behaviors)?

Research Hypothesis 2: Individuals with a perceived physical or emotional disability will have lower adherence to blood glucose monitoring.

Specific Aim 3: There is a large cost associated with diabetes and blood glucose monitoring, yet there is a lack of data surrounding specific financial, occupational, or physical stressors that affect the adherence to one's diabetes self-management. This study looks to examine specific financial, physical, and occupational challenges in adherence to blood glucose monitoring from the NHANES dataset.

Research Question 3: What is the relationship of specific financial, physical, and occupational challenges and adherence to blood glucose monitoring?

Research Hypothesis 3: Individuals with a limited income, no insurance, or who have significant physical impairments will lead to lower adherence in blood glucose monitoring.

Overview of Study Design and Strategy

This study was designed to assess differences and similarities in adherence of diabetes blood glucose monitoring through the lens of sociodemographics, perceived physical/psychosocial barriers, and financial stressors. This study analyzed the cross-sectional NHANES datasets ranging from 2013-2020 (Pre-Pandemic), utilizing weighted binomial regressions.

Chapters 2 and 3 took archival data from previous NHANES 2013-2018 data cycles cross-sectional study to examine the relationships between age, gender, duration illness and individual's perceived barriers, physical, psychological, and emotional disability, and blood glucose adherence. The goal of the proposed study was to conduct secondary data analysis to identify differences in perceived barriers by age group in adherence.

Participants were a minimum of 18 years of age. The exclusion criteria were under eighteen, those not diagnosed with diabetes, and missing data pertaining to the outcome variables. These manuscripts used weighted negative binomial linear regressions to account for the complex study design of NHANES. Both manuscripts utilized SAS v9.4 (SAS Institute Inc., Cary, NC) for analyses.

Table 1.1: Description of Variables Utilized in Manuscript 1

Variable Type	Study Variable	Variables Description	Variable Types	Range
N total = 560				
Dependent	Frequent of blood glucose	# of times checked blood glucose	Numeric	1 to 15 times
Independent	Gender	Female/Male	Dichotomous	
Moderating	Age	Age of Individual	Continuous	18-96 years
	Duration of illness	Length of having Diabetes	Continuous	1-68 years
Control	Race/Ethnicity	Race or Ethnicity of Individual	Categorical	White
				Black Hispanic Other

Table 1.1 reflects the dependent, independent, moderating, and control variables utilized in manuscript one. The dependent variable was number of times checked blood glucose, which ranged from 1-15 times, those who refused to answer, marked zero or had missing data were excluded. The independent variable was gender. Coded dichotomously as 1 for males and 0 for females. The moderating variables were age at survey conducted, ranging from 18-96 years. Also, duration of illness was assessed as a potential moderating variable, ranging from 1-68 years. Finally, race/ethnicity was utilized as the control variable where analyses were run twice to account for the potential race/ethnicity differences. This had four categories: White, Black, Hispanic, and Other. Other descriptive

variables were used, such as: household income, marital status, education level, covered by health insurance, and general health status. Overall, this study sample was 560. In addition, study population flowcharts are in each respective manuscript detailing the sample size calculations and exclusion criterion factors. Furthermore, Chi-Square analyses were run to assure there was no interdependence among variables.

Table 1.2: Description of Variables Utilized in Manuscript 2

Variable Type	Study Variable	Variables Description	Variable Types	Range
N total = 1447				
Dependent	Frequent of blood glucose	# of times checked blood glucose	Numeric	1 to 15 times
Independent	Perceived Health Status	Self-perception of health	Categorical	5 levels:
				Excellent, very good, good, fair, poor
Moderating	Disability Status	Self-perception of Disability	Dichotomous	Yes/No
Control	Race/Ethnicity	Race or Ethnicity of Individual	Categorical	White
				Black
				Hispanic
				Other

Table 1.2 reflects the dependent, independent, moderating, and control variables utilized in Chapter 3. The dependent variable was number of times checked blood glucose, which ranged from 1-15 times, those who refused to answer, marked zero or had missing data were excluded. The independent variable was perceived health status. Coded into five levels ranging from Excellent to poor. The moderating variable was disability status, which was dichotomously coded “1” and “0”, for “Yes” and “No”, respectively. Finally, race/ethnicity was utilized as the control variable, where analyses were run twice to account for the potential race/ethnicity differences. This had four categories: White, Black, Hispanic, and Other. Other descriptive variables were also outlined, such as: household income, marital status, education level, and general health status. Overall, this study sample

was 1447. Furthermore, Chi-Square analyses were run to assure there was no interdependence among variables.

Chapter 4 used NHANES Pre-Pandemic data (2017- March 2020). Ordinarily, these datasets are distributed in two-year cycles by the CDC; however, given the more limited sample size exacerbated by SARS-CoV-2, the 2019-2020 years were lumped-in with the 2017-2018 data cycles. The goal of the proposed study was to conduct secondary data analysis to identify differences in physical, financial, and occupational challenges by age group in adherence. Again, the participants were 18 years and older. The exclusion criterion was under eighteen, those not diagnosed with diabetes, and missing data pertaining to the outcome variables. These manuscripts used weighted negative binomial regressions to account for the complex study design of NHANES. This manuscript utilized SAS v9.4 (SAS Institute Inc., Cary, NC) for analyses.

Table 1.3 Description of Variables Utilized in Manuscript 3

Variable Type	Study Variable	Variable Description	Variable Types	Range
N=1318				
Depedent	Frequency of blood glucose	# times check Blood Glucose	Numeric	1-150
Independent	Health Insurance	Covered by Insurance	Dichotomous	"yes", "no"
	Health Insurance	Prescriptions Covered	Dichotomous	"yes", "no"
	General Health Condition	Health Condition of Individual	Categorical	Excellent
				Very Good
				Good
				Fair
				Poor
	How many times seen PCP	# times seen PCP in 12 months	Dichotomous	1-6 times, 6+ times
	Occupation	Employed	Dichotomous	"yes", "no"
	Age	Age of Individual	Continuous	18+
	Gender	Gender of Individual	Dichotomous	Male/Female
	Race	Race/Ethnicity of Individual	Categorical	Mexican American
				Other Hispanic
				Non-Hispanic White
				Non-Hispanic Black
				Multiracial
				Unknown

Table 1.3 reflects the dependent and independent variables utilized in manuscript three. The dependent variable was number of times checked blood glucose, which ranged from 1-15 times, those who refused to answer, marked zero or had missing data were excluded. The independent variables were covered by health insurance. Coded dichotomously, as “Yes” or “No”. Time when respondents did not have any health coverage, coded as “Yes” or “No”. Number of times seeing your primary care physician in 12 months, ranging from 1-5 times and 6+ times. Finally, occupational status, dichotomously coded into two levels. The age at survey conducted variable, ranged from 18-96 years. Race/Ethnicity had six categories: Mexican American, Non-Hispanic White,

Non-Hispanic Black, Other Hispanic, Other Race/Multiracial and Unknown. Overall, this study sample was 1318.

The first manuscript (Chapter 2) represents innate factors that individuals may not have any control over: age, gender, and race, which may contribute to a barrier in diabetes self-management practices. These characteristics coupled with the quaternary variable of duration of illness, may affect potential adhering measures tied to diabetes blood glucose monitoring; a vital measure in controlling one's diabetes.

Chapter 2

Age, Gender, Duration of Illness and Blood Glucose Monitoring

Authors: Nicolette Powe, DrPH, MS, MCHES[1]; Jacob Marvin, MS, CPH[1]; Francisco Olivia, MS[1]

Author Affiliations: Department of Health Professions, Bitonte College of Health & Human Services, Youngstown State University, Youngstown, OH[1]

ABSTRACT

Background: Relationships between demographic characteristics and adherence to diabetes self-management practices have been investigated in the past, but the relationship among gender, age, and self-monitoring of blood glucose levels; and other self-management practices require future research. This article examined the relationship between gender, age, duration of diabetes, and adherence to blood glucose monitoring.

Research Design and Methods: Data from the National Health and Nutrition Examination Survey (NHANES) 2013-2014, 2015-2016, and 2017-2018 of adults grouped into ages of 18 years to 39 years, 40 to 60 years, and 61+ were analyzed. These age categories were used to examine the relationships between age, gender, duration of diabetes, and self-monitoring of blood glucose levels in the United States. Weighted negative binomial regressions were used to analyze these relationships.

Results: Gender and duration of illness showed statistically significant effects on the age categories of 18-39 and 40-60 years old. However, the association between self-monitoring of blood glucose levels and either duration of illness or gender were not statistically significant for individuals aged 61 and older. This was irrespective of controlling with and without race/ethnicity.

Conclusion: Results from this study may help health education specialists and other healthcare professionals determine which groups of individuals are at highest risk for poor

adherence to specific blood glucose monitoring. Health promotion interventions may be developed to address the importance of self-monitoring blood glucose levels, despite age, gender, and duration of illness.

Introduction

By 2060, 60.6 million people in the United States (U.S.) are projected to have diabetes.[1] As of 2018, there were 34.2 million Americans with the disease.[2] Uncontrolled high blood glucose can produce diabetic ketoacidosis and coma (short-term complications) and heart disease, stroke, kidney failure, damage to the eyes, and a variety of infections (long-term complications).[3-4] While, there is limited data on average age of diagnosis for Type 2 Diabetes; however, research has shown that an average lifespan can decrease 10-15 years post-diabetes diagnosis and the age 45-64 years yielding the highest rate of new diabetes diagnoses.[5-6] Excluding comorbities, the average life expectancy for a Type 2 diabetic is roughly 80 years, approximately the same as the general population.[5] However, there is a large separation between males and females in respect to life expectancy post-diabetes diagnosis. Diabetic males live on average 7.5 years less compared to their non-diabetic male counterparts; similarly, diabetic females live 8.2 years less than their non-diabetic counterparts, with more men than women being diagnosed per year.[6-7]

There is no overall cure for diabetes, but individuals diagnosed with the disease can undertake measures to prevent diabetes complications or even fully reverse their Type 2 Diabetes by engaging in self-management practices. One way to prevent diabetes complications is through the use of blood glucose monitoring. The American Diabetes Association self-management "gold standard" recommendation consists of monitoring blood glucose levels two to three times per day.[2] Studies suggest that blood glucose monitoring improves the potential outcomes of both Type 1 and Type 2 Diabetes and improves overall A1c (average blood glucose levels over three months' time).[8] By self-monitoring blood glucose, individuals can assess their level of hyperglycemia or hypoglycemia, potentially leading them to make lifestyle modifications.[8]

The relationship among age, gender, and diabetes-self management practices revealed several important findings pertaining to at-home blood glucose monitoring. According to Vincze, Barner and Lopez, of those participants diagnosed with diabetes, just over half (52%) of them were considered adherent to self-monitoring of their blood glucose.[9] In previous studies, women reported having better diet and self-monitoring blood glucose behaviors; but higher BMIs, higher blood pressure and higher Alc when compared to men due to psychosocial factors, such as more depressive symptoms and less familial support.[10] Comparatively, Ruggiero et al. reported there is a separation across age categories in diabetes self-management practices, where dieting and blood glucose monitoring increased with age.[11] Additionally, those who expressed awareness of the potential outcomes and complications of their condition, were the most adherent to diabetes self-management practices.[11]

Furthermore, a longer duration of illness with Type 2 Diabetes has been associated with several diabetes complications including diabetic retinopathy, neuropathy, and nephropathy, and micro-and macroangiopathies.[12]

Researchers have explored the relationship between individual demographic characteristics and adherence to self-management practices, but further research is necessary to comprehend this complex relationship between age, gender, and self-monitoring of blood glucose levels adherence.[13] The relationship between the duration of Type 2 diabetes and the adherence to blood glucose monitoring has also not been adequately studied.[13] Therefore, the need to control blood glucose levels through self-management practices such as diet, exercise, and medicine is key to preventing diabetes complications.

The primary purpose of this study was to assess age and gender differences in blood glucose monitoring from a cross-sectional study of the United States (U.S.) population.

Survey Design and Data Collection:

This was a cross-sectional study using archival NHANES data from 2013-2014, 2015-2016, and 2017-2018 cycles to examine the relationships among age, gender, duration of diabetes illness, and adherence to blood glucose monitoring among individuals over the age of eighteen living in the U.S. with diagnosed diabetes. The NHANES datasets consist of a multitude of surveys that provide a comprehensive assessment of the American population pertaining to nutrition and health. The NHANES data provided information on health and nutrition status, select chronic diseases, and health and nutrition behavior practices of approximately 5,000 adults every year in the United States.

The study population was derived from adults who were 18 and over (N = 12,350). Those excluded were under the age of 18 (N= 7,841), those not diagnosed with diabetes (N= 10,727), and missing data pertaining to the outcome variable (N= 148). The final study cohort was comprised of 560 adults diagnosed with self-reported diabetes.

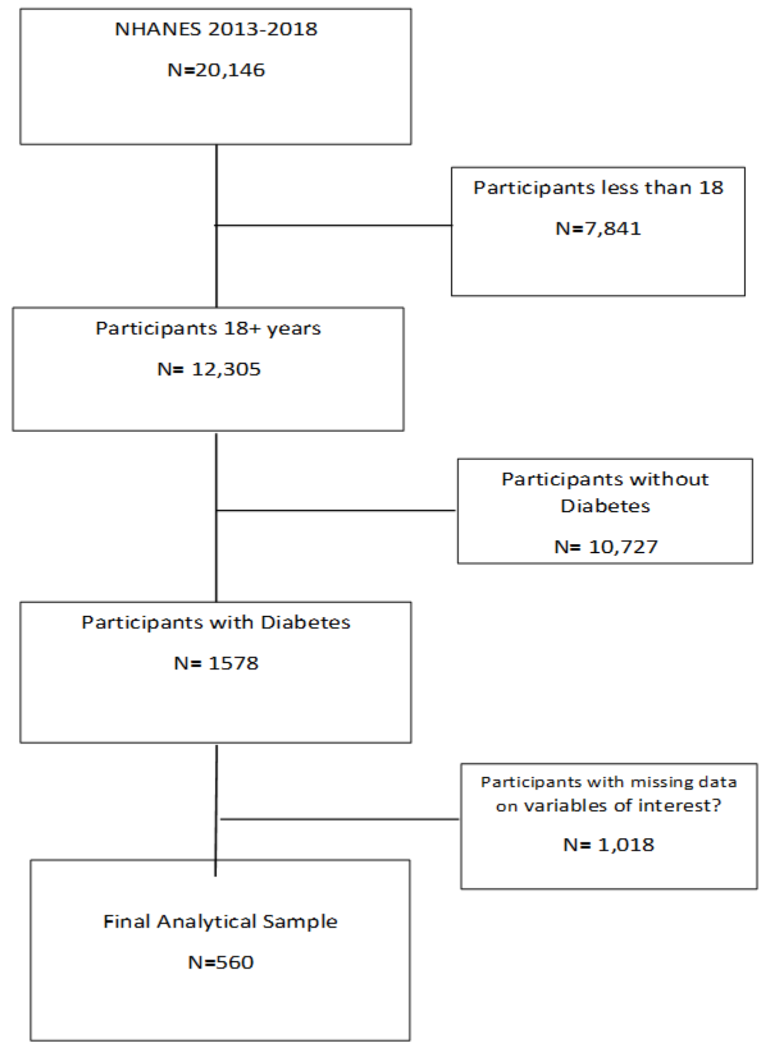


Figure 2.1 Study Cohort Flow Chart

Study Variables:

Outcome Variable

The outcome of interest in this study was blood glucose monitoring. This numeric variable was derived from the question, "How often they check blood for glucose/sugar"? Those that responded as having checked their blood glucose at least once was factored into the analyses. Individuals that marked zero, had missing data or refused to answer were excluded.

Independent Variables

The primary independent variable was gender. Age and duration of illness were examined to determine a moderating effect. To assess if race/ethnicity was a confounding factor, analyses were run twice: once with the race/ethnicity variable and once without.

Statistical analysis:

Study sample characteristics were described by means and standard deviation for continuous variables and proportions for categorical variables for the total population and by sex.

A *t*-test was used to assess how males and females varied across study variables included in the analysis. Weighted negative binomial regressions were used for the dichotomous and categorical variables, respectively. Negative binomial regression was selected to account for over-dispersion in the data. Regression was conducted to analyze the relationships between the 18- 39, 41-60, and 61+ age brackets and gender, duration of diabetes, and self-monitoring of blood glucose levels. All estimated and statistical tests which were weighted to adjust for the complex NHANES survey design and a p-value <0.05 was considered statistically significant. All analyses were performed using SAS v9.4 (Research Triangle Park, NC).

Results

Descriptive statistics are presented in Table 2.1. There were 297 men (53.0%) and 263 women (47.0%). The mean age of respondents was 37 (3.13) years of age, and the mean duration of illness was 12 years (11.61). The majority of respondents reported their health status as good (39.9%) to very good or excellent (38.8%), with fair or poor health reported by 19.7% and 1.6%, respectively. Overall, blood glucose monitoring was reported by 81.4% of respondents.

Characteristics that were significantly different between males and females were education level, marital status, and perceived health status ($p<.0001$). Men reported the most education (57.3%), while women had a higher percentage of graduating high school (53.5%). Those who were in the age 18-39 age bracket, 47.5% reported earning over $75,000. Men reported a higher percentage of any marital status, including being separated at 63.4%, being never married at 59.6%, and being divorced (55.7%). Moreover, those that reported to have less than a high school were in the 61+ age bracket (48.0%). Those most likely to check their blood glucose were in the age 18-39 age bracket (42.4%).

Table 2.2 presents the results of the weighted negative binomial regressions performed in this study without race/ethnicity as a control variable, marked by the regression coefficients and asterisked *p*-values of significance. According to Model 1, only the 40-60 ($p<.04$) age group had a statistically significant relationship between gender and blood glucose measurement compared to the age brackets of 18-39 and 61+ ($p>.05$). According to Model 3 and Model 5, neither age nor duration of illness moderated the effect of gender on blood glucose measurement on the 61+ age bracket, ($p>.05$) or the 40-60 (*p*

>.05) age bracket; however, duration of illness and gender shows a statistically significant relationship in 18-39 age bracket (p <.05).

Table 2.3 presents the results of the incidence rate-ratios calculated in this study without race/ethnicity as a control variable. According to Model 1, all age groups (18-39, 40-60, and 61+) had a positive association between gender and blood glucose measurement (IRR= 1.57, IRR= 1.55 and IRR= 1.23), respectively. This data shows that men are more often, in every age bracket, to being adherent to diabetes blood glucose monitoring compared to their female counterparts. There is a 23% -57% greater adherence rate among men to women in the three age categories.

According to Model 2, all age groups (18-39, 40-60, and 61+) had a positive association between gender and age and blood glucose measurement (18-39: IRR= 1.58 and IRR= 2.64. 40-60: IRR= 1.46 and IRR= 1.02. 61+: IRR= 1.20 and IRR= 1.01), respectively. This analysis shows that in the 18-39 age bracket that they are 158% more often going to be adherent if they are male and 264% more often to be adherent if they are in this age group. In the 40-60 age group, male individuals are seen to be 146% more often adherent to blood glucose monitoring; however, age does not seem to be a large variable factor, where the IRR shows to be relatively constant. In addition, the 61+ age group also shows that males are 20% more often to being adherent to blood glucose monitoring than females; however, age does not seem to play a significant role, as the incidence rate ratio is relatively constant.

According to Model 3, all age groups (18-39, 40-60, and 61+) had a positive association between gender (IRR= 1.19, 1.13, 1.6), age (IRR= 2.23, 1.01, 1.02), respectively and blood glucose monitoring. The 18-39 age bracket was 19% more often to being adherent to blood glucose monitoring if they were male and 123% more often to being adherent if age was factored in. The 40-60 age bracket showed males to be 13% more often to be adherent compared to females, but age did not seem to show a significant effect. Further, the 61+ individuals showed the largest separation, where men were 60% more often to be adherent in their blood glucose monitoring. However, the 40-60 and 61+ age groups were shown minimal effect to adhere to blood glucose monitoring when age*gender (40-60 IRR: 1.01 61+ IRR= .99) was factored. While the 18-39 age group showed a large positive association with age*gender and blood glucose monitoring (IRR= 3.1), where this group was 310% more often to adhere to blood glucose monitoring.

In Model 4, 18-39 and 40-60 showed a positive association with gender and blood glucose monitoring (IRR= 1.51 and IRR=1.54). However, 61+ were less often to adhere to blood glucose monitoring when gender was factored in (IRR= .86). In addition, only the 18-39 age bracket, this bracket was 272% to be more adherent in their blood glucose monitoring. Although, 40-60 and 61+ were held constant, where IRR= 1.

Finally, in Module 5, gender in the 40-60 age group and duration of illness in the 18-39 age group were more often to be adherent to their blood glucose monitoring (IRR= 1.52 and 2.75), respectively. In contrast, gender*duration of illness in the 40-60 and 61+ showed us no variability in the odds ratios (IRR =1.0), as well as just duration of illness in the 61+ age group. Finally, both the 18-39 and the 61+ age groups were less often to adhere to blood glucose monitoring, when gender is factored in (IRR= .36 and .86), respectively.

Table 2.4 presents the results of the weighted negative binomial regressions performed in this study with race/ethnicity as a control variable, marked by the regression coefficients and asterisked *p*-values of significance. Similar to the model without the race/ethnicity, there was statistically significant association between gender, duration of illness and self-monitoring of blood glucose in the 18-39 ($p < .05$, $p < .05$) and the 40-60 ($p < .05$, $p < .05$) age groups. However, the 61+ age group did not yield any statistically significant results.

Table 2.5 presents the results of the incidence rate ratios calculated in this study with race/ethnicity as a control variable. According to Model 1, only the 40-60 and 61+ age groups had a positive association between gender and blood glucose measurement (IRR= 1.55 and IRR= 1.23), respectively.

According to Model 2, only the older age groups (40-60 and 61+) had a positive association between gender and age and blood glucose measurement (18-39: IRR= .80 and IRR= .97. 40-60: IRR= 1.46 and IRR= 1.02. 61+: IRR= 1.20 and IRR= 1.01), respectively.

According to Model 3, all age groups (18-39, 40-60, and 61+) had a positive association between gender (IRR= 1.06, 1.14, 1.6), age (IRR= 1.08, 1.01, 1.02), respectively and blood glucose monitoring. However, despite the positive association, the 40-60 and 61+ groups showed a minimal effect in age and blood glucose monitoring. Similarly, the 40-60 and 61+ age groups were shown minimal effect to adhere to blood glucose monitoring when age*gender (40-60 IRR: 1.01 61+ IRR= .99) was factored. While the 18-39 age group showed a positive association with age*gender and blood glucose monitoring (IRR= 1.13).

In Model 4, 40-60 and 61+ showed a positive association with gender and blood glucose monitoring (IRR= 1.55 and IRR=1.22). However, 18-39 were less often to adhere to blood glucose monitoring when gender was factored in (IRR= .41). In addition, every age bracket was fairly constant in their adherence in their blood glucose monitoring, when comparing duration of illness.

Lastly, in Module 5, gender in all age groups (18-39, 40-60 and 61+) group were more often to be adherent to their blood glucose monitoring (IRR= 1.12, 1.52 and 1.20), respectively. Further, duration of illness in the 18-39 age bracket also showed to be more often to be adherent (IRR= 1.02); however, it is minimal. In contrast, gender*duration of illness in all age groups showed us no variability in the incidence rate ratios (IRR =1.0), as well as just duration of illness in the 61+ age group.

Discussion

This study focused on U.S. adults that have self-reported a diagnosis of diabetes to determine the relationship between demographics (gender, age, and duration of diabetes) and adherence to blood glucose monitoring. This study found gender and duration of illness had a statistically significant association on blood glucose monitoring for those 18-39 and 40-60. However, those 61 years of age and over, had a non-significant association with blood glucose monitoring and any of the aforementioned variables (age, gender, and duration of illness).

Gender, coupled with duration of illness may account for differences between the results of this study and results of a previous studies by Kramer et al and McCollum et al.[14-15] Both previous research studies showed conflicted results based on gender and adherence factors to diabetes self-management factors; however, neither study factored in duration of illness. There was a significant moderating effect of the duration of illness on the relationship between gender and blood glucose monitoring, except with respect to the 61+ age category. Age was found not to be a mediating factor in any of the age categories. This affirms the findings of several previous studies, which found that diabetes self-management practices vary by age and duration of diabetes illness.[16-19] Previous studies investigated young adults or elderly individuals and this study focused on adults aged 18 years to 80 accounting for the more difficulties in controlling diabetes such as insulin resistance increases, and glucose tolerance decreases due to aging.[20]

The findings of this study may help support health education specialists and diabetes education care specialists to determine which groups of individuals are at higher risk for poor adherence to specific diabetes self-management practices that focused on adoption of healthy behavioral lifestyle changes such as exercise and physician visit interventions to prevent or delay diabetes complications. Given the key findings of this research being the youngest age group (18-39), having gender and duration of illness being likely factors in the adherence to diabetes blood glucose monitoring, not accounting for race/ethnicity, it is imperative that this age bracket remain vigilant and continuously monitor their blood glucose, especially females and more recently diagnosed diabetes. Additionally, Certified Health Education Specialists (CHES) and Diabetes Care and Education Specialists (DCES) can provide a linkage to community-based interventions, such as the Community Preventive Services Task Force, which looks to monitor and prevent diabetes complications on a more routine basis.[21] For example, continual blood glucose monitoring for Type 2 Diabetes is crucial for early detection of complications associated with diabetes. Furthermore, additional research is needed to investigate why the lack of adherence to diabetes self-management practices and what education is needed to improve adherence to diabetes self-management practices. With the younger age brackets (18-39 and 40-60) having more factors exacerbating a lack of adherence to diabetes self-management practices, it is imperative that early detection and more thorough education/screening process pertaining to diabetes should be incorporated into a healthcare professionals' repertoire to curtail diabetes rates and limit potential complications of diabetes. As an ultimate goal, an improved national policy framework focused on reforming the health systems to deliver improved healthcare, more comprehensive diabetes education, performing screenings to identify abnormal blood glucose levels, and expanding health system-based and community-based implementation of clinical preventive services may help to reduce mortality and morbidity.[22] This could be accomplished through legislators expanded policies allocating monies to improve care for people living with diabetes and reduce variation in outcomes such as require both continuity and integration of services across the entire clinical pathway.[23]

There are several limitations to this study. The cross-sectional nature prevents the establishment of causality. The major limitation is that the respondents are not geographically representative of the United States, where oversampling of a certain geographical area might occur. The self-report format of the NHANES questionnaire could potentially lead to inaccurate reporting of results, which may threaten the validity of the findings. This is especially true for self-reported diagnosis of diabetes or prediabetes and self-management practices. Finally, given the weighted aspect of this analysis and the age bracket groupings, it is unlikely that this study successfully and consistently maintained an 80% power calculation, which this study looked to achieve.

Conclusion

This study aimed to determine blood glucose monitoring between those 18-39, 40-60 and 61+ years of age, with regards to gender, age, and the duration of the illness. This study found that gender and duration of illness had a statistically significant effect on blood glucose monitoring for those 18-39 and 40-60. However, those 61 years of age and over, had a non-significant relationship with blood glucose monitoring and any of the aforementioned variables (age, gender, and duration of illness). The data yielded in this study agreed with some of the existing literature; however, given the added number of sociodemographic variables included in the analysis, the data addressed previous gender separations in diabetes blood glucose monitoring. As those diagnosed with diabetes continue to rise, this study shows that further intervention and integration of mitigating factors are warranted to curtail the variation of outcomes of those diagnosed with diabetes. These data may be useful for health professionals to recognize which sociodemographic groups of individuals are at highest risk for poor adherence to diabetes blood glucose monitoring, such as those 18-39 with a shorter duration of illness. In addition, promotion interventions, such as educational strategies and the addition of prevention task forces must be developed to address the importance of self-monitoring blood glucose levels, irrespective of age, gender, and duration of illness.

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TABLES

Table 2.1 Characteristics of study participants for total sample and sex

	Total (n=560)	Female (n=263)	Male (n=297)	Age 18 -39	Age 40 -60	Age 61 +	P-value*
Sociodemographics							
Sex (% "Male")		47.0%	53.0%	20.2%	15.9%	17.0%	
Age (Mean, SD)	37 (3.13)	38.5(3.54)	35.4(3.05)	29 (2.75)	50 (2.56)	71 (6.68)	<.0001
Duration of illness (Mean, SD)	12(11.61)	12(11.57)	12(11.67)	4(2.57)	6(9.2)	21(26.55)	<.0001
Race/ethnicity (%)							<.0001
White	37.7%	56.9%	43.1%	61.4%	30.8%	7.8%	
Black	26.8%	53.3%	46.7%	54.9%	32.3%	12.8%	
Hispanic	8.2%	47.8%	52.2%	38.7%	32.6%	28.7%	
Other	27.3%	49.0%	51.0%	47.4%	33.7%	18.9%	
Annual household income (%)							<.0001
<$34,999	45.9%	55.1%	44.9%	43.6%	29.4%	27.0%	

$35,000 - $74,999	30.0%	48.9%	51.1%	35.9%	35.9%	28.2%	
>$75,000	24.1%	52.5%	47.5%	47.5%	32.9%	19.6%	
Marital status (%)							<.0001
Never Married	20.5%	40.4%	59.6%	76.2%	15.6%	8.2%	
Married	53.7%	49.5%	50.5%	25.4%	31.7%	42.9%	
Separated	4.9%	36.6%	63.4%	34.6%	53.9%	11.5%	
Divorced	11.4%	45.3%	55.7%	11.5%	45.9%	42.6%	
Living with partner	9.5%	49%	51%	66.7%	27.5%	5.8%	
Education (%)							<.0001
<HS	19.5%	47.2%	52.8%	22.4%	29.6%	48.0%	
HS	39.4%	53.5%	46.5%	40.0%	33.0%	27.0%	

≥ HS	41.1%	42.7%	57.3%	44.7%	30.2%	25.1%	
Health insurance (%)							<.0001
Yes covered	89.6%	63.2%	36.8%	40.2%	29.6%	30.2%	
No covered	10.4%	78.2%	21.8%	50.0%	27.6%	22.4%	
Blood Glucose Monitoring (%)							<.0001
Checked blood glucose	81.4%	78.7%	21.3%	42.4%	28.8%	28.8%	
Did not check blood glucose	18.6%	82.7%	17.3%	36.5%	30.8%	32.7%	
Health status (%)							<.0001
Excellent or very good	38.8%	43.9%	56.1%	24.4%	15.9%	59.7%	
Good	39.9%	45.5%	54.5%	26.9%	17.4%	55.7%	
Fair	19.7%	48.0%	52.0%	17.6%	19.2%	63.2%	

Poor	1.6%	50.0%	50.0%	30.0%	10.0%	60.0%	

Table 2.2 Weighted Negative Binomial Regression by Blood Glucose Monitoring (without race/ethnicity control variable)

	(1)	(2)	(3)	(4)	(5)
How often {do you check your/does SP check his/her} blood for glucose or sugar? Age 18-39					
Gender	-0.796	-0.785	-1.768	-0.90	-1.03
Age		-0.034	-0.217		
Age x Gender			0.1205		
Duration of Illness				-0.002	0.01*
Duration of Illness x Gender					-0.02 *
How often {do you check your/does SP check his/her} blood for glucose or sugar? Age 40-60	(1)	(2)	(3)	(4)	(5)
Gender	0.44*	0.38*	0.12	0.43*	0.42*
Age		0.02	0.007		
Age x Gender			0.005		

Duration of Illness				-0.002	-0.04*
Duration of Illness x Gender					0.0002

How often {do you check your/does SP check his/her} blood for glucose or sugar? Age 61+	(1)	(2)	(3)	(4)	(5)
Gender	0.21	0.18	0.47	-0.15	-0.156
Age		0.013	0.02		
Age x Gender			-0.006		
Duration of Illness				-0.003	-0.004
Duration of Illness x Gender					0.0001

Note **p<.05, Model (1): Control Variables and Gender, Model (2): Control Variables, Gender, and Age, Model (3): Control Variables, Gender, Age, and Age x Gender, Model (4): Gender and Duration of Illness, Model (5): Gender, Duration of Illness, and Gender x Duration of Illness*

Table 2.3 Incidence Rate Ratios by Blood Glucose Monitoring (without race/ethnicity control variable)

18-39 without race/ethnicity	(1)	(2)	(3)	(4)	(5)
Gender	1.57	1.58	1.19	1.51	0.36
Age		2.64	2.23		
Age*Gender			3.10		
Duration of Illness				2.72	2.75
Gender*Duration of Illness					0.98
40-60 without race/ethnicity	(1)	(2)	(3)	(4)	(5)

Gender	1.55	1.46	1.13	1.54	1.52
Age		1.02	1.01		
Age*Gender			1.01		
Duration of Illness				1.00	0.96
Gender*Duration of Illness					1.00
61+ without race/ethnicity	(1)	(2)	(3)	(4)	(5)
Gender	1.23	1.20	1.60	0.86	0.86
Age		1.01	1.02		
Age*Gender			0.99		
Duration of Illness				1.00	1.00
Gender*Duration of Illness					1.00

Note: Model (1): Control Variables and Gender, Model (2): Control Variables, Gender, and Age, Model (3): Control Variables, Gender, Age, and Age x Gender, Model (4): Gender and Duration of Illness, Model (5): Gender, Duration of Illness, and Gender x Duration of Illness

Table 2.4

Weighted Negative Binomial Regression by Blood Glucose Monitoring (with race/ethnicity control variable)

	(1)	(2)	(3)	(4)	(5)
How often {do you check your/does SP check his/her} blood for glucose or sugar? Age 18-39					
Gender	-1.98	-0.22	0.06	-0.90	0.11
Age		-0.03	0.08		

Age x Gender			0.12		
Duration of Illness				-0.01	0.02*
Duration of Illness x Gender					0.004*

How often {do you check your/does SP check his/her} blood for glucose or sugar? Age 40-60	(1)	(2)	(3)	(4)	(5)
Gender	0.44*	0.38*	0.13	0.44*	0.42*
Age		0.02	0.01		
Age x Gender			0.005		
Duration of Illness				-0.002	-0.04*
Duration of Illness x Gender					0.002

How often {do you check your/does SP check his/her} blood for glucose or sugar? Age breakdown 61+	(1)	(2)	(3)	(4)	(5)
Gender	0.21	0.18	0.47	0.20	0.18
Age		0.01	0.02		
Age x Gender			-0.006		
Duration of Illness				-0.003	-0.001
Duration of Illness x Gender					0.004

Note **p<.05. Model (1): Control Variables and Gender, Model (2): Control Variables, Gender, and Age, Model (3): Control Variables, Gender, Age, and Age x Gender, Model (4): Gender and Duration of Illness, Model (5): Gender, Duration of Illness, and Gender x Duration of Illness*

Table 2.5 Incidence Rate Ratios by Blood Glucose Monitoring (with race/ethnicity control variable)

18-39 with race/ethnicity	(1)	(2)	(3)	(4)	(5)
Gender	0.14	0.80	1.06	0.41	1.12
Age		0.97	1.08		
Age*Gender			1.13		
Duration of Illness				0.99	1.02
Gender*Duration of Illness					1.00
40-60 with race/ethnicity	(1)	(2)	(3)	(4)	(5)
Gender	1.55	1.46	1.14	1.55	1.52
Age		1.02	1.01		
Age*Gender			1.01		
Duration of Illness				1.00	0.96
Gender*Duration of Illness					1.00
61+ with race/ethnicity	(1)	(2)	(3)	(4)	(5)
Gender	1.23	1.20	1.60	1.22	1.20
Age		1.01	1.02		
Age*Gender			0.99		
Duration of Illness				1.00	1.00
Gender*Duration of Illness					1.00

Note: *Model (1): Control Variables and Gender, Model (2): Control Variables, Gender, and Age, Model (3): Control Variables, Gender, Age, and Age x Gender, Model (4): Gender and Duration of Illness, Model (5): Gender, Duration of Illness, and Gender x Duration of Illness*

The second manuscript (Chapter 3) segues from external contributory factors in blood glucose monitoring to emotional and perception-based contributory factors in blood glucose monitoring for Type 2 Diabetes. This manuscript shifts from non-modifiable factors to behavioral and emotional factors in adherence. This manuscript is the basis for the conceptual framework behind this dissertation. A study like this never has been conducted to address health behavior in this manner using the Health Belief Model (HBM) with a nationally representative database. This manuscript will be submitted to the Diabetes Care Journal for submission Fall 2022.

Chapter 3

Perception of Health, Physical, Psychological, and Emotional Disability and Blood Glucose Monitoring Among People with Diabetes

Authors: Nicolette Powe, DrPH, MS, MCHES[1]; Jacob Marvin, MS, CPH[1]; Francisco Olivia, MS[1]; Naomi Modeste, DrPH, CHES®[2]; Diadrey-Anne Sealy, PhD[3]; Vonna Lou Caleb Drayton, DrPH; Colwick Wilson, PhD[5].

Author Affiliations: Department of Health Professions, Bitonte College of Health & Human Services, Youngstown State University, Youngstown, OH[1]; School of Public Health, Loma Linda University[2]; School of Science, Technology and Allied Health, University of the Southern Caribbean[3]; Civil and Commercial Group, Booz Allen Hamilton[4]; Provost, Oakwood University [5].

ABSTRACT

Background: Diabetes continues to be a rapidly escalating public health issue. Mitigation strategies have centered around preventing and controlling diabetes through self-management practices focused on blood glucose monitoring. This study analyzed how blood glucose monitoring was affected by the perceptions of health, physical, psychological, and emotional disability in people with diabetes.

Methods: Using the 2013-2014, 2015-2016 and 2017-2018 United States National Health and Nutrition Examination Survey (NHANES) dataset of individuals with diabetes. This cross-sectional study was designed to analyze the relationships among perceived health status (perceived benefits); level of physical, psychological, and emotional disability (perceived barriers); and adherence to blood glucose monitoring in the United States. Weighted negative binomial regressions were performed to analyze these relationships and apply the Health Belief Model (HBM) to a nationally representative sample of individuals with diabetes.

Results: Respondents who identified as having a physical, emotional, or psychological disability were less likely to engage in physical activity. However, when controlling for race/ethnicity, there was still a statistically significant relationship between disability status and likelihood of engaging in physical activity and less likely to visit a physician, which agrees with other findings. Results from the regressions performed without and with race/ethnicity as a control variable suggested that there was statistically significant relationship between perceived health status and blood glucose monitoring.

Conclusion: Currently, no study has applied the HBM to the NHANES dataset representative of the US population of individuals with diabetes to study blood glucose monitoring. Results may suggest that physical disability and psychological barriers possibly interfere with regular exercise which is supported by previous research and supports predictions of the HBM.

Introduction

Diabetes remains a growing public health issue for society with a prevalence of 30.3 million cases.[1] Efforts to prevent and control diabetes, support self-management practices focused on lifestyle modifications for the maintenance of proper glycemic control. Several studies have demonstrated the effectiveness of blood glucose monitoring in diabetes self-management lifestyle modifications, which may prevent complications and poor outcomes for millions of individuals with diabetes.[2,3] However, for many individuals, adherence to blood glucose monitoring is problematic.

Background

Difficulties for individuals with diabetes vary by race, age, gender, and socio-economic status suggesting that two types of individual barriers, physical and psychological, prevent adequate blood glucose monitoring.[4,6-8] Psychological distress associated with diabetes includes feelings of helplessness, frustration, and lack of motivation. These feelings can prevent individuals from adhering to blood glucose monitoring.[5,6] Physical disabilities, such as renal failure, neuropathy, and pain associated with diabetes and eye disease, also prevent individuals from implementing adequate exercise, proper nutrition, and medication adherence.[4] As a result, this may cause unsafe or harmful blood glucose levels. There are also environmental and health system barriers to self-management that are outside the control of individuals with diabetes.

To explain the relationships between these barriers and adherence to blood glucose monitoring, this study used the Health Belief Model (HBM) as a theoretical framework. HBM explains and predicts individual changes in health behaviors. As an individual's perceived threat to diabetes (perceived susceptibility), belief of consequence (perceived severity), potential positive benefits of action (perceived benefits), perceived barriers to action, exposure to factors that prompt action (cues to action), and confidence in ability to succeed (self-efficacy) are associated with the greater likelihood of engaging in health-promoting behaviors.[9,10] (Figure 3.1). Although there are updated conceptual models of the HBM, Figure 3.1 was selected because it illustrates the research questions as investigated in this study to predict the likelihood of engaging in a particular health-promoting behavior.

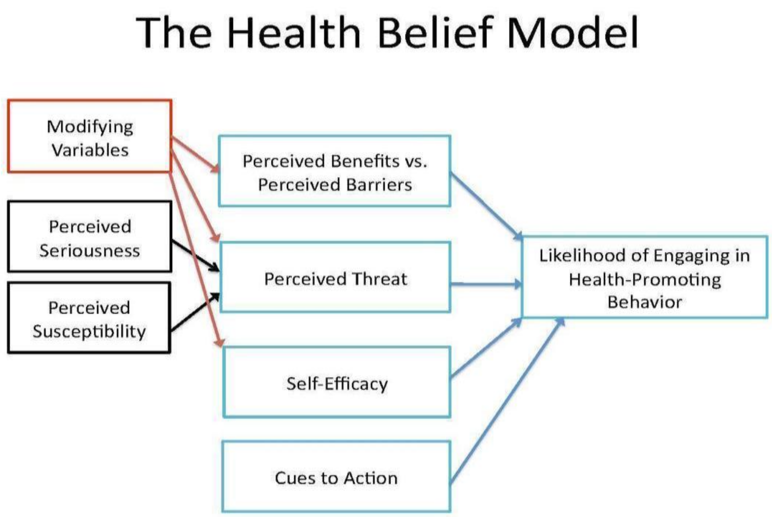

Figure 3.1: Relationships among the constructs of the HBM, modifying variables, and the likelihood of engaging in health-promoting behavior (Stretcher, 1997).

The HBM has been applied to comprehend adherence to diabetes self-management practices as it relates to regimen compliance, and Marshall and Becker found that the HBM was useful for explaining noncompliance and designing compliance-enhancing interventions.[11] Also, the validity of the HBM scales in patients with diabetes was investigated.[12] The HBM demonstrated adequate internal consistency in all scales that were assessed, and it showed association with greater self-report adherence to medication. The authors concluded that the HBM exhibited both reliability and validity in the individuals with diabetes.

However, these studies did not apply the HBM to a nationally representative dataset to examine the relationship between individuals with diabetes' perceived health status (perceived benefit), between perceived health status and blood glucose monitoring. This study investigates the relationship between perceived threat and health behavior. Perceived threat is operationalized by individuals with diabetes' perception of their health status, and the likelihood of engaging in health-promoting behavior is adherence to diabetes self-management practices by the frequency of blood glucose monitoring. The relationship between level of physical, psychological, and emotional disability (perceived barrier), and adherence to blood glucose monitoring (outcome behavior) among individuals with diabetes was investigated.

Survey Design and Data Collection

This was a cross-sectional study using archival NHANES data from 2013-2014, 2015-2016 and 2017-2018 cycles, to examine the relationships among perceived health status, disabilities, and adherence to blood glucose monitoring among individuals over the age of eighteen living in the U.S. with diagnosed diabetes. The NHANES datasets consist of a multitude of surveys aiming to provide a comprehensive assessment of the American population pertaining to nutrition and health through random sampling. The NHANES data provided information on health and nutrition status, select chronic diseases, and health and nutrition behavior practices of approximately 5,000 adults every year in the U.S.

The study population was derived from adults who were 18 and over (N = 12,305). Those excluded were under eighteen, those not diagnosed with diabetes, and missing data pertaining to the outcome variable. The final study cohort was comprised of 1447 adults (Fig. 3.2).

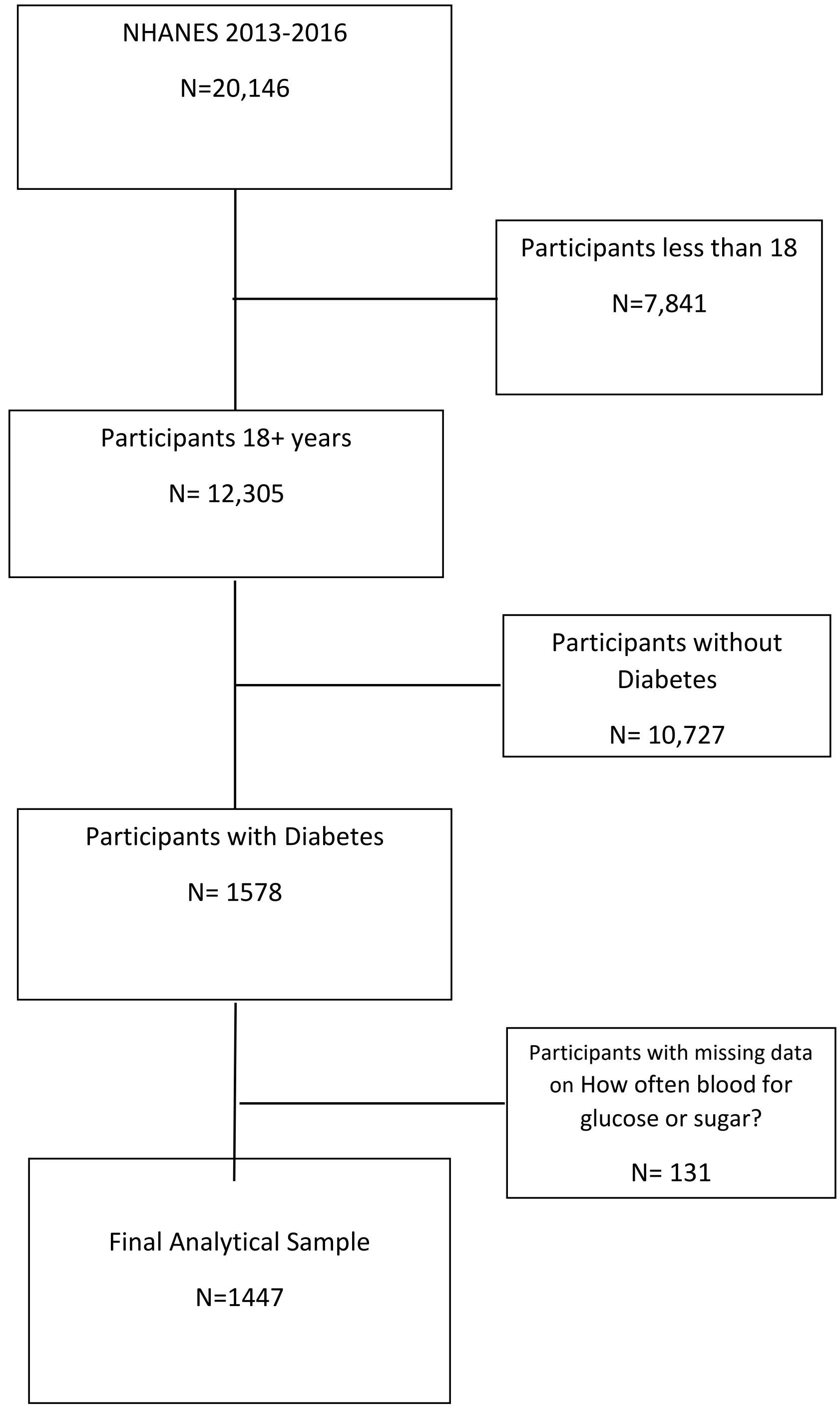

Figure 3.2 Study Population Flow Chart

Study Variables:
Outcome Variable

The outcome of interest in this study was blood glucose monitoring. This numeric variable was derived from the question "DID260 - How often check blood for glucose/sugar"? Those that responded as having checked their blood glucose at least once was factored into the analyses. Individuals that marked zero, had missing data or refused to answer were excluded.

Independent Variables

The primary independent variable was perceived health status, which represents 'perceived threat' in the HBM. The disability variable was examined to determine a moderating effect. The disability variable was coded dichotomously, where those who had a disability coded as "1", all others were coded "0". Other factors known to be associated with blood glucose monitoring, such as household income, marital status and education were included as covariates. To assess if race/ethnicity was a confounding factor, analyses were run twice, once with the race/ethnicity variable and once without.

Data analysis

Before data analysis was conducted, data cleaning was performed. Data were merged and individuals who did not receive a diabetes diagnosis, or who were under the age of eighteen were excluded from the dataset. Although no variables were recoded, NHANES variables were relabeled as described above. Descriptive statistics were computed with means and standard deviations for continuous variables, including age and duration of illness. Counts and percentages were calculated for participant's gender, marital status, race/ethnicity, and education level.

To examine the relationships among perceived health status (perceived benefits); level of physical, psychological, and emotional disability (perceived barriers); and adherence to blood glucose monitoring, analysis was performed twice using the control variables with and without race/ethnicity. To analyze the research questions, weighted negative binomial regression models were used to examine the relationship between each dependent variable. The control variables were entered into the model. Then, each predictor (independent) variables were entered into the model and each of the two-outcome diabetes self-management behavior variables were analyzed using weighted negative binomial regression analysis. All estimated and statistical tests which were weighted to adjust for the complex NHANES survey design and a *p*-value <0.05 was considered statistically significant. All analyses were performed using SAS v9.4 (Research Triangle Park, NC).

Results

Descriptive statistics are presented in Table 3.1. There were 731 men (51.0%) and 702 women (49.0%). The mean age of respondents was 59.8 (SD = .50) years of age, and the mean duration of illness was 11.41 years (SD = .45). The majority of respondents reported their health status as good (40.9%) to very good or excellent (15.6%), with fair or poor health reported by (33.0%) and (10.5%). Overall, blood glucose was reported by 99.1% of respondents.

Significantly different characteristics between males and females were annual household income, being married, being separated, and perceived health status.

For this study, the results were generated when weighted negative binomial regression was performed for each of the two dependent variables (diabetes self-management behavior). The study results used regression to analyze the statistical significance of perceived health status and level of psychological, or emotional disability.

Table 3.2 presents the results of the weighted negative binomial regressions performed without race/ethnicity as a control variable. In summary, there were statistically significant relationships between perceived health status and adherence to blood glucose monitoring, while showing a small effect that those that perceive their health as a barrier to their health are more often to adhere to blood glucose monitoring compared to those without those personal health perceptions (IRR= 1.08, $p < .0001$).

Also, in Table 3.2 the relationship between perceived physical, emotional, or psychological disability and blood glucose monitoring was analyzed using weighted negative binomial regression analysis. Moreover, the results showed statistically significant relationships between physical, emotional, or psychological disability and the frequency of blood glucose monitoring. Moreover, this shows that those that believe they are disabled in some manner are 30% more often adherent to blood glucose monitoring (IRR= 1.3, $p = .04$).

Table 3.3 presents the results of the weighted negative binomial regressions performed in this study with race/ethnicity as a control variable. Similar to the model without the race/ethnicity, frequency of blood glucose monitoring and disability status were statistically significant (IRR= 1.35, $p =.03$) and showed a moderate effect of blood glucose monitoring. Furthermore, frequency of blood glucose monitoring and perceived health status were statistically significant (IRR= 1.07, $p =.002$), and showed a similarly minimal effect to that without race.

Discussion

This study analyzed how blood glucose monitoring was affected by the perceptions of health, physical, psychological, and emotional disability in people living with diabetes. First, it should be noted that there were statistically significant relationships between perceived health status, or disability status, and blood glucose monitoring. Having a physical disability may pose challenges to adequate diabetes self-management, and physical disabilities are significantly more prevalent among individuals with diabetes than those without due to the comorbidities associated with diabetes, among older adults or of middle age.[13] These findings support the need to address the multiple barriers related to diabetes care, specifically, self-management practices.[4,6] This research leads to the awareness that the barriers to successful diabetes self-management practice may be diabetes related. Long-term physical barriers preventing adequate exercise include nephropathy leading to renal failure and dialysis, neuropathy, and possible subsequent diminished sensation, paresthesia, muscle weakness, amputation, and limited dexterity. Long-term physical barriers also include eye disease leading to diminished visual capacity and vascular disease potentially leading to hemiplegia. Occasionally, the severity of a barrier and the level of self-management may be interdependent.[4] For example, patients with gastroparesis may exhibit improvement in the barrier with enhanced glycemic control, and improvement in gastroparesis symptoms may make glycemic control easier to achieve.

Psychological barriers may also account for the finding that patients with emotional or psychological disabilities were less likely to engage in blood glucose monitoring. The feeling of helplessness and frustration contributed to poor adherence to self-management practices, as did depression.[5] Further, positive attitudes of surveyed participants were associated with better self-management results. However, according to Moström et al., the top three reported reasons for not performing more frequent self-monitoring of blood glucose were lack of time, not remembering, and self-consciousness.[14] Moreover, some individuals just do not think glucose monitoring is important. According to Mumu et al., the main barrier to adherence to blood glucose monitoring was that they did not feel it is important (81%).[15]

These findings agree with the predictions of the HBM model and do support the application of the HBM model to diabetes self-management. This research shows that perceived barriers and perceptions of self, can and do affect outcome health behaviors. However, with the estimated $245 billion spent in 2012 on direct and indirect cost of diagnosed diabetes, reducing the average medical expenditures for people with diabetes is critical, and health-education programs using the HBM may improve age group and gender interventions.[16] As an example, the Michigan Model of Health has been utilized and implemented in Michigan schools, where students have learned components of the HBM, thus improving knowledge, self-efficacy, and social support systems.[17] This program, in turn, could reduce the notions of perceived barriers to disease self-management, while reducing healthcare costs if programs of this type are initiated in schools country-wide.

There are several limitations to this study. The largest of which is the very small sample size of the "Perceived Disability Status" variable, where the respondents said "Yes". With this small sample, there may not be an accurate representation of the data, despite the weighting scheme of the regression analysis; thus, it may overgeneralize the general population. However, if this variable were to be taken out, the narrative of this study would shift to only include perceptions of health and may not tell the whole story regarding perceived barriers to blood glucose monitoring. Moreover, the cross-sectional nature prevents the establishment of causality. The self-reported format of the NHANES questionnaire could lead to inaccurate reporting of results, which may threaten the validity of findings. Since the NHANES questionnaire was not designed for use with the HBM, items from the NHANES questionnaire may not perfectly operationalize HBM constructs. The HBM does not lend itself to an exact relationship with ecological data such as NHANES; thus, generalizations were made to make these connections.

Conclusion

There was a statistically significant relationship between physical, emotional, or psychological disability (perceived barriers) and frequency of blood glucose measurements as predicted by the HBM model. Moreover, perceived disability status showed a small effect of individuals 30-35% better at being adherent to diabetes blood glucose monitoring compared to those that do not share those perceptions. Further, data demonstrated a relationship between perceived health status (perceived benefits) and adherence to self-management practices, as predicted by the HBM model. Despite the positively statistically significant values of the incidence rate ratios and the *p*-value, given that the IRR is very small it is unlikely to be clinically meaningful.

Through the development of specific treatment guidelines for men and women. This includes recognizing age group differences to self-management practices based on physical, psychological, and emotional disability factors.

This study demonstrates that physical, psychological, and emotional disability may inhibit proper blood glucose monitoring behaviors. Thus, it is recommended that the relationship between the perceived barriers, HBM dimension, and health behavior be considered in the design of health education programming. More specifically, it may be necessary for health education specialists and other healthcare professionals to develop interventions that make blood glucose monitoring easier for individuals with diabetes who are experiencing a physical disability. As an example, an automatic continual blood glucometer may be an excellent alternative to conventional blood glucose monitoring equipment. Devices like these take out the timing aspect, as they are on timed intervals for measurement. Also, this would be an appropriate alternative who have experienced neuropathy in the hands and fingers, so individuals do not have to continually pricking their fingers. Moreover, further research is necessary to explore health beliefs and diabetes' perceived health status (perceived benefit and threats in the health belief model) and their adherence to diabetes self-management practices. This future research may unlock future successful intervention methodologies addressing non-compliance of diabetes self-management practices.

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Figure 3.1 Relationships among the constructs of the HBM, modifying variables, and the likelihood of engaging in health-promoting behavior (Stretcher, 1997)

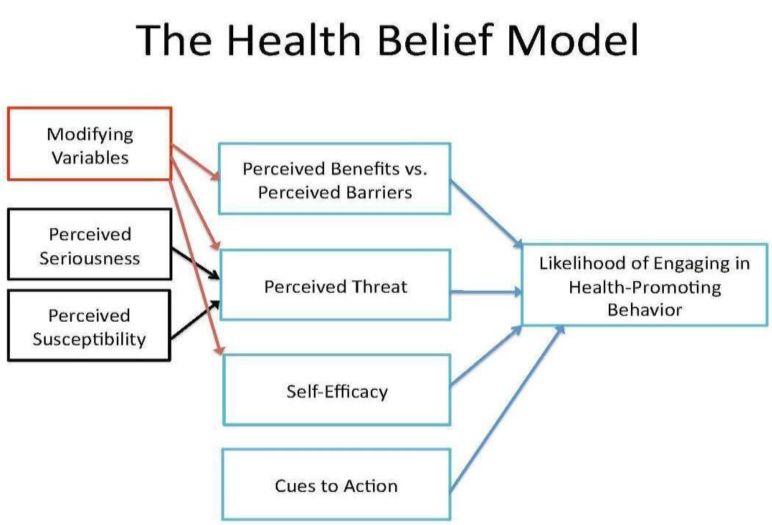


Table 3.1.
Description of the Sample

Variable	Value	*N*	%	Mean	SD
Age		1433		59.8	.50
Duration of Illness				11.41	.45
Perceived Health Status				3.36	.11
Disability Status	Yes	28	4.0		
	No	665	96.0		
Gender	Male	731	51.0		
	Female	702	49.0		
Household Income	$0 to $34,999	714	49.8		
	$35,000 to $74,999	368	25.7		
	Over $20,000	78	5.4		
	Under $20,000	29	2.0		
	$75,000 to $100,000+	183	12.8		
	Refused to Disclose	45	3.1		
	Don't Know	16	1.1		
Marital Status	Married	744	51.9		

	Widowed	247	17.2		
	Divorced	200	14.0		
	Separated	55	3.8		
	Never Married	137	9.6		
	Living with Partner	42	2.9		
	Unknown	8	.6		
Education Level	Less than 9th Grade	278	19.4		
	9th-11th Grade	267	18.6		
	High School Grad/GED	296	20.7		
	Some College or AA	346	24.1		
	College Graduate or Above	237	16.5		
	Unknown	9	0.7		
Race/Ethnicity	Mexican American	182	12.7		
	Other Hispanic	154	10.8		
	Non-Hispanic White	481	33.6		
	Non-Hispanic Black	386	26.9		

	Other Race – Including Multiracial	176	12.3		
	Unknown	54	3.7		

Table 3.2

Weighted Negative Binomial Regression by Diabetes Self-Management Practice (without race/ethnicity control variable)

How often {do you check your/does SP check his/her} blood for glucose or sugar?	Estimate	95% CI	IRR	p-value
HEALTH STATUS	0.0774	[0.3531, 0.6564]	1.08	<.0001
DISABILITY 'Yes'	0.2647	[-0.7428, 0.2947]	1.30	0.04

Table 3.3

Weighted Negative Binomial Regression by Diabetes Self-Management Practice (with race/ethnicity control variable)

How often {do you check your/does SP check his/her} blood for glucose or sugar?	Estimate	95% CI	IRR	p-value
HEALTH STATUS	0.067	[-0.3384, 0.0758]	1.07	0.002
DISABILITY 'Yes'	0.2962	[-0.8615, 0.2997]	1.35	0.03

The final manuscript (Chapter 4) details potential financial or occupational challenges limiting one's ability to properly care for themselves, which may contribute to a lack of adherence to diabetes self-management practices. The limitation to medical care provides a final and well-rounded argument for the inhibition of being adherent to diabetes self-management practices, specifically blood glucose monitoring. This manuscript will be sent to *Health Services Research & Managerial Epidemiology* Journal and has been sent to *Health Education & Behavior* Journal.

Chapter 4

Financial and Occupational Challenges and Blood Glucose Monitoring in Type 2 Diabetes

Authors: Jacob Marvin, MS, CPH[1] Nicolette Powe, DrPH, MS, MCHES[1]

Author Affiliations: Department of Health Professions, Bitonte College of Health & Human Services, Youngstown State University, Youngstown, OH[1]

ABSTRACT

Background: Blood glucose monitoring effects are changing for people living with Type 2 Diabetes. However, there is a lack of recent data surrounding financial, occupational, or physical stressors that affect the adherence of diabetes self-management practices. This article looks to examine specific financial, physical, and occupational challenges in adherence to blood glucose monitoring in Type 2 Diabetes.

Methods: Data from the National Health and Nutrition Examination Survey (NHANES) 2017-2020 Pre-Pandemic data of adults 18+ were analyzed. These data were used to examine the relationships between insurance coverage, health status, occupation, and self-monitoring of blood glucose levels in the United States.

Results: This study found that respondents had a statistically significant association with seven variables: prescription drug coverage (in-part or full), occupation status, gender, age, and three race subcategories (non-Hispanic White, Black, and Other-Multiracial).

Conclusion: This study may help certified health education specialists (CHES) and diabetes care and educator specialists (DCES) to better identify which groups of individuals are at highest risk for poor adherence to specific blood glucose monitoring in Type 2 Diabetes.

Introduction

In 2017 alone, there was an estimated cost of 327 billion dollars spent on diagnosed diabetes in the US.[1] In fact, 1 in every 4 dollars associated with healthcare is attributed to diabetes care.[1] In a survey conducted by SingleCare, it is approximated that 54% of individuals paid for their diabetes care out-of-pocket.[2] Generally, those afflicted with diabetes have medical expenses more than twice as high, compared to those not diagnosed with diabetes.[1] Further, those that are uninsured with diabetes are less likely to seek medical advice, and less likely to perform daily blood glucose monitoring, than those with private health insurance.[3]

There is no overall cure for diabetes; although, it can be managed to a near cure, accounting for different types of diabetes, duration of how long an individual has had the disease and the severity of the disease. However, individuals diagnosed with the disease can undertake measures to prevent diabetes complications and manage their condition by engaging in self-management practices. Self-management practices refer to an individual's role in managing their chronic disease through methods of support and prevention. One way to prevent diabetes complications is through the use of blood glucose monitoring.

The American Diabetes Association self-management "gold standard" recommendation consists of monitoring blood glucose levels two to three times per day.[4] Blood glucose monitoring requires lancing the fingertip to obtain a drop a blood sample that is applied to a test strip and inserted in a glucose meter device for measurement reading. By self-monitoring blood glucose, patients can assess their level of hyperglycemia or hypoglycemia, potentially leading them to make lifestyle modifications.[3]

According to Vincze, Barner and Lopez,[5] those diagnosed with Type 2 diabetes, slightly over half (52%) were considered adherent to self-monitoring of their blood glucose. Moreover, Ruggiero et al. reported there is a separation across age categories in diabetes self-management practices, where blood glucose monitoring increased with age.[6]

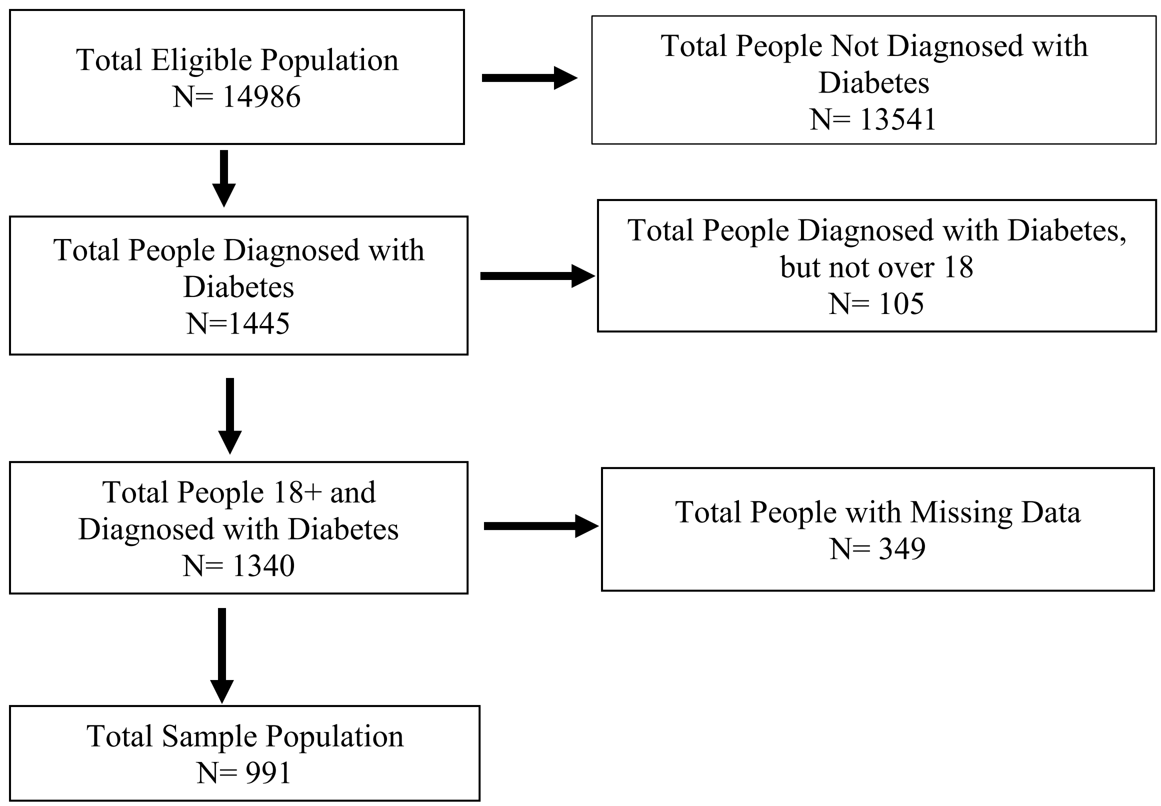
The relationship between occupational status, financial status, and insurance coverage among those diagnosed with Type 2 Diabetes and the adherence to blood glucose monitoring has not been adequately studied. Therefore, exploring the potential contributory factors that affect the adherence to diabetes self-management, especially factors that an individual may not think about (financial status, occupation status, etc.) is key to preventing potential diabetes complications.

This study was designed to analyze the relationships among specific financial and occupational challenges and adherence to blood glucose monitoring in the United States. In doing so, this article looks to inform Certified Health Education Specialists (CHES) and Diabetes Care and Education Specialists (DCES) professionals identify which groups of individuals are at highest risk for poor adherence to specific blood glucose monitoring.

Survey Design and Data Collection:

This was a cross-sectional study using archival NHANES data from 2017-2020 Pre-Pandemic data cycle to examine the relationships among insurance coverage, occupation, general health condition, and adherence to blood glucose monitoring among individuals over the age of eighteen living in the U.S. with diagnosed diabetes. The NHANES datasets consist of a multitude of surveys that provide a comprehensive assessment of the American population pertaining to nutrition and health. The NHANES data provided information on health and nutrition status, select chronic diseases, and health and nutrition behavior practices of approximately 5,000 adults every year in the U.S.

Figure 4.1: Flowchart of Study Population



Study Variables:

Outcome Variable

The outcome of interest in this study was blood glucose monitoring. This numeric variable was derived from the question "How often check blood for glucose/sugar"? Those that responded as having checked their blood glucose at least once was factored into the analyses. Individuals that marked zero, had missing data or refused to answer were excluded.

Independent Variables

The primary independent variables were insurance and prescription coverage, general health condition, number of times having seen a physician in the past 12 months, occupation status, age, gender, and race.

Statistical analysis:

Study sample characteristics were described by means and standard deviation for age and frequencies for categorical variables for the total population.

Weighted negative binomial regressions were used for assessing all variables. Negative binomial regression was conducted to analyze the relationships between individuals 18+ and insurance coverage, general health condition, occupation status, and self-monitoring of blood glucose levels. All estimated and statistical tests which were weighted to adjust for the complex NHANES survey design and a *p*-value <0.05 was considered statistically significant. All analyses were performed using SAS v9.4 (Research Triangle Park, NC).

Results

Descriptive statistics are presented in Table 4.1. There were 473 men (47.7%) and 518 women (52.3%). The mean age of respondents was 38 (.82) years of age. The majority of respondents reported their health status as good (29.2%) to very good or excellent (51.8%), with fair or poor health reported by 15.6% and 3.4%, respectively. Overall, blood glucose monitoring was reported by 99.3% of respondents. The bulk of respondents (87.9%) stated that they actually have insurance, while of that percentage, 94.7% health insurance covers any part of a prescription. Many respondents (91.5%) reported to have seen a physician between 1-5 times in the past six months. Largely those surveyed were unemployed (50.5%).

Table 4.2 presents the results of the weighted negative binomial regressions performed in this study. The variable subcategories listed as having "-" were used as reference categories for the analysis. Individuals eighteen and older had a statistically significant relationship with the prescription drug coverage, having a job, age, gender, and three categories of race/ethnicity (White, Black, and Other-Multiracial). It was found that between having insurance and blood glucose measurement was not statistically significant (p = .59) and 25% less often to check their blood glucose compared to those who do not have insurance. However, if the insurance covered at least part of a prescription, it was found was deemed to have a statistically significant positive association (p = .04) and were 150% more often to engage in blood glucose monitoring compared to their non-prescription coverage counterparts. General health status proved to be non-statistically significant in every subcategory of health among the respondents (p > .05). However, those who deemed themselves in fair or good health were 189% and 197%, respectively, more often to engage themselves in blood glucose monitoring. In contrast, self-reported poor and very good individuals were 9% and 25%, respectively, were less often to engage themselves in checking their blood glucose levels. In addition, individuals did not have a significant relationship with having seen a physician in the past twelve months if they were seen less than 6 times (p = .11), although it did show this group to be 148% more often to engage in blood glucose monitoring. In the type of job category, there was a negative statistically significant association between having a job and this study population (p < .0001), where those that were employed were less often to engage themselves in blood glucose monitoring, compared to being unemployed (IRR= 0.49). Those that were documented as having been non-Hispanic White (IRR=1.51, p = .01), Black (IRR= 2.51, p < .0001) or Other-Multiracial (IRR= 5.60, p < .0001) were all statistically significant, while being an unknown (p = .07) or being another Hispanic race (p = .24) were deemed non-significant. Similarly, those that were non-statistically significant were also less often to engage in blood glucose monitoring, where another Hispanic race and unknown race were IRR= 0.78 and 0.63, respectively. Moreover, this data shows that non-Hispanic Whites are 51% more often to be engaged in blood glucose monitoring. Also, non-Hispanic Black and Other-Multiracial individuals are the most often to be adherent to blood glucose monitoring, where those groups are 151% and 560%, respectively. Furthermore, gender and age were both statistically significant (p <.0001), with younger-aged individuals being slightly negatively associated and less often to check their blood glucose (IRR= .97) and gender being moderately positively associated and with women more often to check their blood glucose (IRR=1.51).

Discussion

This study focused on U.S. adults diagnosed with diabetes to determine the relationship between financial, occupational, and physical challenges or stressors and adherence to blood glucose monitoring. This study aimed to determine relationships between blood glucose monitoring among those 18+ years of age, with regards to insurance coverage, general health status, and occupation.

This study found 18+ aged respondents had an association with seven variables: prescription drug coverage (in-part or full), occupation status, gender, age, and three race subcategories (White, Black, and Other-Multiracial).

The results from this study are similar to that of Harris, where those uninsured had was a higher proportion of diabetes complications, such as glycosuria and hyperglycemia.[7] Moreover, it mirrors complaints of participants in Adu et al., where financial burden, due to lack of insurance was a large contributor to lack of adherence in blood glucose monitoring.[8] In addition, the data from this study does agree with the findings of Mehrotra et al. where it was found there was a concrete relationship between occupational status and blood glucose monitoring.[9] However, participants in Adu et al. study, were reported as having commented that it wasn't the occupational status, rather what sector of the workforce accounted for their lack of adherence to diabetes self-management.[8] Furthermore, Mostrom et al. found adherence to be low when all supplies for monitoring are provided free of charge by the Swedish healthcare system so finances alone will not explain it.[10]

In summary, there are many at-risk groups that have been identified as a heightened threat for non-adherence to their blood glucose monitoring regimen. Those include employed individuals, those that are covered by their insurance, individuals that believe they are in very good health, and those of a Hispanic or Unknown race. The findings of this study may assist health education specialists and diabetes care education specialists to identify which sociodemographics or at-risk groups are at a heightened threat for poor adherence to diabetes self-management, specifically blood glucose monitoring. This new knowledge will be useful to create a specific plan for these high-risk non-adherent individuals designed to prioritize lifestyle modifications and adherence in checking blood glucose levels more frequently, whilst curtailing the increased likelihood for diabetes complications. Moreover, a CHES/DCES can provide linkage to care to a community-based organization that can assess and monitor an individual's blood glucose levels on a more routine basis. In addition, linking a social worker to an at-risk individual can be useful given the heightened predisposition to non-adherence of blood glucose monitoring and potential issues with insurance or prescription coverage. All of these intervention strategies should be utilized to combat diabetes complications as these can manifest in numerous forms such as: Uncontrolled high blood glucose can produce diabetic ketoacidosis and coma (short-term complications) and heart disease, stroke, kidney failure, damage to the eyes, and a variety of infections (long-term complications).[11-12]

In addition, targeted approaches towards the youngest age demographic is warranted, given that prescription drug coverage has a significant relationship with adherence to blood glucose monitoring; thus, it is imperative that sustained coverage is maintained throughout a lifetime. This is due to the likelihood of severe diabetes complications if those diagnosed with diabetes are not adherent to self-management practices from early onset diagnoses.

Moreover, maintenance of physical health is vital in the elderly age population, specifically pertaining to adherence of blood glucose monitoring. With this age population being the most at-risk for developing diabetes and the most susceptible to severe complications, it is crucial that prevention efforts and physical well-being are maintained to ensure strong adherence to blood glucose self-management.[13-14]

Finally, while utilizing CHES and DCES may be an excellent strategy to augment poor adherence to blood glucose monitoring, education does not necessarily resolve financial issues that an individual may face. Therefore, given the results of this study, it is imperative for legislators to know that paying for blood glucose monitoring services might lower overall costs to taxpayers. Healthcare can become quite costly to the taxpayer; thus, if specific allocation of funding is made for these services, it may increase adherence to diabetes self-management. In doing so, making diabetic individuals healthier and experiencing less diabetes-related complications, while reducing taxpayer costs for healthcare.

There are several limitations to this study. The cross-sectional nature prevents the establishment of causality. The major limitation is that the respondents are not randomly selected and are not geographically representative of the United States. The self-report format of the NHANES questionnaire could potentially lead to inaccuracies of results, which may threaten the validity of the findings. This is especially true for self-reported diagnosis of diabetes, undiagnosed diabetes or prediabetes and self-management practices. Finally, those that were marked for checking their blood sugar at least once, were considered adherent to diabetes self-management practices. This might inflate numbers of those that are truly adherent to checking their blood glucose.

Moreover, further research is necessary to explore specific occupations to assess potential relationships among different sectors of the workforce and their potential effects those occupations may have on adherence to blood glucose monitoring. In addition, the specific type of insurance an individual carries is a potential key element in extrapolating the barriers of adherence to diabetes self-management. Furthermore, conducting a geographically nationally representative sample would be useful in determining the needs of certain geographical areas of the U.S. and the general populations of the U.S.

Conclusions

This study found that respondents had a statistically significant association with seven variables: prescription drug coverage (in-part or full), occupation status, gender, age, and three race subcategories (White, Black, and Other-Multiracial).

With the number of individuals diagnosed with diabetes rises with time, this study exemplifies that there are numerous financial, occupational, and physical challenges that may not be considered factors contributing to adherence to diabetes self-management, specifically blood glucose monitoring, in an individual living with diabetes. Intervention and mitigation methodologies are warranted to limit the disparity in contributory variables in the lack of adherence to diabetes self-management, specifically blood glucose monitoring.

These data may be useful for health professionals, such as: CHES and DCES to recognize which sociodemographic groups of individuals are at heightened predisposition for poor adherence to diabetes self-management practices specifically blood glucose monitoring. Moreover, promoting interventional strategies, such as diet, physical activity or medication adherence must be stressed to convey the overall importance of self-monitoring blood glucose levels, irrespective of financial, occupational, and physical challenges.

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Table 4.1: Descriptive Statistics of Variables

Variable	Value	*N*	%	Mean (years)	SD (years)
Age		991		38	0.82
Gender	Male	473	47.7		
	Female	518	52.3		
Race/Ethnicity	Mexican American	120	12.1		
	Other Hispanic	114	11.5		
	Non-Hispanic White	343	34.6		
	Non-Hispanic Black	251	25.3		
	Other Race – Including Multiracial	100	10.1		
	Unknown	63	6.3		
Covered by insurance	Yes	871	87.9		
	No	120	12.1		
Does it cover any part of prescription	Yes	938	94.7		
	No	53	5.3		
GENERAL HEALTH CONDITION	Excellent	259	26.1		
	Very GOOD	255	25.7		
	GOOD	288	29.2		
	FAIR	155	15.6		
	POOR	34	3.4		
HAVE YOU SEEN A DOCTOR IN PAST 12 MONTHS	1-5 TIMES	907	91.5		
	6+ TIMES	84	8.5		
WHAT TYPE OF JOB WORKING	Has a Job	491	49.5		
	Does not Have a Job	500	50.5		
Table 4.1 describes the frequencies of each of the independent variables and their subcategories studied					

Table 4.2: Negative Binomial Regressions

Variable				
n=991	**Estimate**	**95% CI**	**IRR**	**p-value**
Covered by Insurance: 'Yes'	-0.2854	[-1.3150, 0.74423]	0.75	0.59
Covered by Insurance: 'No'	-	-	-	-
Do plans cover Prescriptions: 'Yes'	0.4032	[0.0218, 0.7846]	1.50	0.04
Do plans cover Prescriptions: 'No'	-	-	-	-
General Health Condition				
Very Good	-0.2885	[-1.0144,0.4375]	0.75	0.44
Good	0.6366	[-0.0625, 1.3356]	1.89	0.07
Fair	0.6754	[-0.0246, 1.3753]	1.97	0.06
Poor	-0.0984	[-0.8397, 0.6429]	0.91	0.8
Excellent	-	-	-	-
#Times receive healthcare over 12 months				
1-5 Times	0.3886	[-0.0889, 0.8660]	1.48	0.11
6+ Times	-	-	-	-
Type of work done last week				
Has a Job	-0.7129	[-0.9072, -0.5187]	0.49	<.0001
Does Not Have a Job	-	-	-	-
Race/Ethnicity				
Other Hispanic	-0.2464	[-0.6561, 0.1634]	0.78	0.24
Non-Hispanic White	0.412	[0.1036, 0.7205]	1.51	0.01
Non-Hispanic Black	0.9201	[0.5725, 1.2678]	2.51	<.0001
Other Race – Including Multiracial	1.7219	[1.3210, 2.1228]	5.60	<.0001
Unknown	-0.4596	[-0.9541, 0.0349]	0.63	0.07
Mexican American	-	-	-	-
Age	-0.0328	[-0.0397, -0.0260]	0.97	<.0001
Gender				
Female	0.4091	[0.2315, 0.5866]	1.51	<.0001
Male	-	-	-	-

Table 4.2 describes regression coefficients, 95% confidence intervals, exponential regression coefficient and p-values of independent variables included in weighted negative binomial regression. Abbreviations: - = Reference Category from Regressions

Chapter 5

This chapter will conclude the study by reviewing key findings pertaining to the aims of the research, as well as the future implications of the findings. Finally, it will discuss the limitations associated with the research and the future recommendations based on research findings.

This research aimed to investigate and discuss the potential contributory factors in adherence diabetes blood glucose monitoring. These results show that sociodemographics, specifically duration of illness with or without gender was significant in the 18-39 age bracket, irrespective of race/ethnicity. In the 40-60 age group, gender and duration of illness showed having a significant relationship with being adherent to blood glucose monitoring, regardless of race/ethnicity. Finally, the 61+ age group had no variables of significant consequence, regardless of race/ethnicity.

Moreover, this research this aimed to investigate perceived health and disability status and the adherence to diabetes blood glucose monitoring. The overall results indicated that, irrespective of race/ethnicity, perceived health and disability status show a significant relationship in being adherent to blood glucose monitoring.

Finally, this research looked to assess the role of financial, occupational, and physical challenges as it relates to diabetes blood glucose monitoring. This study found 18+ individuals had an association with several variables: prescription coverage, occupational status, gender, age, and race.

Through the three separate research studies, the research indicates there are numerous factors: physical, emotional, or financial, any and all can affect the conduct and adherence to diabetes blood glucose monitoring.

This research has addressed the problem of what barriers may exist contributing to a lack of adherence or non-adherence to blood glucose monitoring by adding additional knowledge to the literature assessing confounding and inter-dependent sociodemographic factors on diabetes self-management. Moreover, this research has added another tool using the HBM for potential management/prevention, which gives professionals and practitioners another piece of information to account for when a non-adherent diabetic patient is in their care. Further, these studies have agreed with current literature that is discussed below. Finally, this study has contributed to the field of health education, as this details mental health and physical health limitations, but also limiting external factors that some practitioners may not account for when providing care or making treatment plans.

Largely, diabetes research has focused on individual sociodemographics and adherence to blood glucose monitoring has been studied; however, this particular research focused on a collective of primary sociodemographic factors like age, gender, race, and the adherence to blood glucose monitoring. Combining these variables investigated the potential confounding attributes each sociodemographic variable affected each other. Added information gained may allow for selective targeting of specific demographic types, in order to assist with being adherent to self-management practices, like blood glucose monitoring.

The second manuscript provided some novelty in the area of health education and epidemiology, where we applied the Health Belief Model (HBM) to a nationally representative dataset, like NHANES. This analysis had never been done. Investigating the potential barriers and challenges that may exist in a national populous is key in establishing relationships that may assist practitioners with identifying a gap or trend that extends beyond state lines, across gender, age, and race. Consequently, this study sheds light on what variables may affect diabetes self-management within multiple demographics nationwide. Having a collective idea of what can curtail or manipulate the rate of diabetes in America is key in the bettering of the health of its residents.

With such a large cost associated with diabetes, having knowledge dissected down is key in understanding what emotional, financial, or occupational stressors are counterproductive to adherence in diabetes blood glucose monitoring. This information showed what measures are missing or ineffective in adults, making those diagnosed with diabetes compliant and/or non-compliant with their self-management of their blood glucose.

The first manuscript affirmed the notion that age, and duration of illness were significant factors to adherence in adherence to diabetes blood glucose monitoring.[15-18] Similarly, in the second manuscript, the study affirmed the relationship that the HBM would predict the behaviors of those with perceived barriers and perceived benefits to diabetes self-management. Thus, it implicated the future application of the HBM for use in the self-management of diabetes. The third manuscript solidified the notion that having insurance of any coverage is crucial to the diabetes self-management process. Finally, occupational status details your level of compliance with diabetes self-management of your blood glucose. Therefore, this study agrees with current research/theories pertaining to diabetes self-management practices, which includes blood glucose monitoring.

Physicians, social workers, health educators, diabetes care education specialists (DCES), and employers alike are implicated in the applicability of this study. Physicians need to be cognizant of the age demographic, race, and gender with whom they are working. This study places heavy importance on being adherent with blood glucose monitoring. Coming from a health educator or mental health profession perspective, it may be wise to manipulate the Health Belief Model (HBM) to fit the needs of the patient to ensure compliance with a medical regimen. Also, working with underinsured patients can always be a struggle in practice; however, adjusting a medical plan to fit the financial and medical needs are key in adherence and better quality of life. Social workers need to be mentioned as they function as the bridge between medical professionals and patients. Understanding the patient's potential financial constraints or mental health issues could be the difference between a patient taking their meds, checking their blood sugar, et cetera or being non-complaint and suffering severe consequences from diabetes. When counseling patients afflicted with diabetes, it is key for health education specialists or certified diabetes educators to truly inform patients of their risks for severe disease, the imperativeness of strictly following a self-management regiment while accounting for external factors like race, insurance status, or perceived health status. Comparatively, employers also play a part. Underinsuring, underpaying or not insuring their workers who are burdened with any chronic disease, including diabetes is counterproductive to the health of the worker and to the place of employment. Diabetes has a broad range of effects it can portray at any given moment in time, spanning from loss of limb to blindness to death. All these suboptimal effects of diabetes can be prevented by allowing for more money and coverage, so that the worker can receive their diabetes medication; they can get a blood glucose monitor; have strips for the monitor, etc. Certainly, these things can not only keep an employee working and healthy but just may save a life in the process.

There are few limitations to this study. All manuscripts consist of a cross-sectional design; therefore, causality cannot be established. Additionally, the self-reporting format of NHANES can introduce a level of self-reporting bias. Third, while NHANES is nationally representative to the U.S., it may not be geographically representative of the entire U.S. There is potential that there are different people each data cycle who may oversample certain populations or states. Finally, there could be an investigator reporting bias, where there was improper reporting or limited reporting by test analysts.

This study holds numerous future implications for researchers, with the newfound knowledge of the wide-ranging issues that can affect one's ability or adherence to diabetes self-management, specifically relating to blood glucose monitoring. Moreover, given the large dataset NHANES is, more data can be pulled out of the numerous categories of variables to assess the significance or a relationship between additional NHANES variables and diabetes blood glucose monitoring. There is a large number of potential relatable variables that could potentially impact one's ability to be adherent. Assessing those new variables, could potentially unlock a new correlation/relationship and further increase the knowledge of practitioners and individuals afflicted, alike.

Given the SARS-CoV-2 pandemic, that has affected the world many times over, there have been reports that COVID-19 has indeed caused diabetes in individuals.[19] Given the novelty of the virus, and the likelihood of the virus continuing to be a part of life for the foreseeable future, it would be of interest to see how the rates of diabetes have increased since the COVID-19 pandemic. A multi-country longitudinal study would be of interest to show the true effect COVID-19 has caused on diabetes and to address other potential long-term effects after contracting COVID-19.

A topic this study had not discussed as part of our exclusion criterion was children under eighteen. This age demographic is crucial in terms of prevention. Educating this generation on the importance of healthy lifestyle habits, as well as a regular exercise regimen could put decades on their lives; in addition to save them from the loss of limb and other detrimental effects from diabetes. This age group is also important too, as there is increasing research shown that children that have contracted COVID-19 have a larger likelihood of acquiring diabetes.[19] In two separate datasets, researchers saw a 31-166% increase in children diagnosed with COVID-19 versus not contracting COVID-19.[19] It is also of note that these studies were only conducted for a single year, ending in March of 2021; thus, there is ample data now able to be collected for another full-year.[19] This study could play well into variants and sublineages of COVID-19 affecting diabetes rates. Did the alpha variant, the delta variant or the omicron variant cause more children to acquire diabetes? Similarly, countries outside of the Unites States faced other subtypes that were not large contributors in the US. For instance, the gamma variant in Brazil or the beta variant in South Africa, could have potentially impacted children and adults, alike.

Another topic of interest for future research would be reducing the age-limit of these studies aforementioned. Since children were among the exclusion group, it would be interesting to see if children under eighteen follow the same mannerisms and beliefs of their older counterparts. Does gender or specific-age matter in blood glucose monitoring? Does how you believe in yourself matter? Does how you see yourself matter? Does it matter if your guardians have insurance or how long has it been since you have seen your family physician (GP)? All these questions would be great research items to investigate, given the considerable number of children now afflicted with diabetes.

With diabetes rates skyrocketing in America, having a better idea of key factors that make an individual compliant in management of their diabetes is imperative for the health of Type II diabetic Americans. This research has shown that there are several non-modifiable attributes and a few external variables that can severely impact one's ability to be self-adherent in their blood glucose monitoring. With this latest research, there are several future research opportunities for children and worldwide to see what serves as a barrier for people and blood glucose monitoring. Medical professionals, employers and diabetics should take note, as knowing key variables affecting adherence in diabetics, could wind-up saving a life.

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