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Predictive Relationship between Treatment Adherence, Glycated Hemoglobin and Diabetic Complications Among Jamaicans

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Abstract

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by

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MD, Windsor University School of Medicine, 2016

MPH, Walden University, 2013

MSc, Northern Caribbean University, 2002

Dissertation Submitted in Partial Fulfilment

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Abstract

Patient nonadherence to physicians' prescribed therapeutic regimen is the greatest challenge in the effective treatment of patients with diabetes worldwide. Scientific evidence has revealed that nonadherence to prescribed medication could result in diabetic complications such as cardiovascular disease, retinopathy, nephropathy, and neuropathic diabetic foot ulcers. The purpose of this study was to explore predictive relationships between levels of adherence to antidiabetic medications, patient HbA1c levels, and diabetic complications among Jamaicans, an understudied population. The research question that guided this study was: Do the patient level of adherence and HbA1c levels have any predictive relationship with the severity of diabetic complications (cardiovascular disease, retinopathy, nephropathy and neuropathic foot ulcer) among Jamaicans after controlling for age and gender? The theory of planned behavior was used to guide the study. Data regarding diabetic complications were collected from 119 records during a cross-sectional review of patient dockets. Level of adherence was determined from an interviewer-administered Morisky 8-item adherence scale. A multiple regression analysis revealed that lower levels of patient adherence to treatment and higher HbA1c levels predicted greater severity of cardiovascular disease ($p = .000$; $p = .000$), retinopathy ($p = .009$; $p = .090$), nephropathy ($p = .007$; $p = .001$) and diabetic neuropathic foot ulcers ($p = .027$; $p = .001$). Findings from this study will contribute to the knowledge base on diabetic medication nonadherence and may encourage health care professionals to advocate for better medication adherence strategies among people with diabetes.

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Dedication

To God be the glory. I dedicate this dissertation to my family (Stacian -Wife, Kindness -Daughter, Christian Jr. Son, Abundance - Daughter) and my brother Chris Nwaukwa.

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With deep and sincere appreciation, I express my gratitude to Dr. Richard Jimenez and Dr. Sandra M. Harris for their endless and relentless professional directives, motivation and support. Many thanks to my wife and kids for their prayers, unwavering support and encouragement all these years.

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Chapter 1: Introduction to the Study

Introduction

Health care providers expect individuals living with diabetes mellitus to have an adequate understanding of the nature of the disease and the treatment options available to treat the disease. These expectations include understanding the role of antidiabetic medications in maintaining glycemic control and the consequence of sustained, uncontrolled hyperglycemia. Individuals living with diabetes should adhere to physicians' prescribed treatment regimens (Arifulla, John, Sreedharan, Muttappallymyalil & Basha, 2014). However, findings from studies have shown that many patients fail to adhere to treatment recommendations. Consequently, many people with diabetes face acute and chronic complications (Amado et al., 2015; Kumar, Abbas & Fausto, 2010). Amado et al. (2015) suggested that nonadherence to treatment compromises a patient's ability to achieve optimal treatment. Khan et al. (2012) argued that there are many reasons why people with diabetes do not adhere to prescribed therapeutic regimens. These reasons include lack of adequate motivations to take prescribed medication, inability to adapt to the lifestyle and behavioral changes essential to maintain glycemic control, and lack of understanding of the severity of diabetic complications. It is also true that some patients become nonadherent because they are unable to keep appointments with both the primary and specialist physicians (Khan et al., 2015). Arifulla et al. (2014) concluded that forgetfulness is one of the most common reasons for nonadherence to antidiabetic medication. Other researchers have identified factors such as side effects of antidiabetic medication, treatment regimen complexities, as well as sociodemographic

status as major factors that influence patient adherence to medication (Arifulla, et al., 2014; Kassahun, Gashe, Mulisa & Rike, 2016). Low adherence translates to uncontrolled diabetes mellitus which is problematic because it compromises the immune system and promotes a number of complications such as retinopathy, nephropathy, cardiovascular diseases, and diabetic neuropathic foot ulcers (Kaul, Ahmad, Tarr, Kohner & Chibber, 2013).

In this chapter, I will summarize empirical literature that forms the background of this study. I will also present the problem statement, the purpose of this study and the research questions. In addition, I will define key terms, discuss the assumptions, scope of the study, delimitations, limitations, and significance of this study.

Background

Diabetes mellitus (DM) has been defined as a metabolic syndrome that targets multiple organs (Kumar, Abbas & Fausto, 2010). Kaul et al. (2013) suggested that diabetes mellitus is a chronic debilitating metabolic disease that has tremendous health, social, and economic consequences. Papadakis and McPhee (2015) argued that DM is a metabolic syndrome that is characterized by inappropriate hyperglycemia which occurs when the pancreatic islet cells malfunction. The dysfunctions of the pancreatic islet cells translate to deficiencies of insulin secretion or insulin resistance or both (Papadakis & McPhee, 2010). As a result, doctors make recommendations for prescriptions drugs that target and correct the metabolic abnormalities to prevent diabetic complications (Papadakis & McPhee, 2015).

According to Khadar et al. (2015) Type 2 DM is characterized by a combination of multiple pathologies which includes insulin resistance, insufficient insulin secretion, and inappropriate glucagon secretion. These complex abnormalities manifest as an array of metabolic dysfunctions that are characterized by hyperglycemia, high levels of free fatty acids, elevated levels of pro-inflammatory cytokines in plasma, decreased glucose transport into muscle cells, increased breakdown of fat, and elevated hepatic gluconeogenesis. All these metabolic abnormalities are common in both Type 1 and Type 2 DM (Khardori et al., 2015). Kumar, Abbas, and Fausto (2010) explicated that DM is more than a disease; rather, it is a group of coordinated metabolic disorders that share a common denominator which is hyperglycemia. Uncontrolled sustained hyperglycemia may have profound consequences that may include damage to major organs and metabolic dysregulations (Kumar et al.,2010).

According to the American Diabetes Association (2014) insulin synthesis, secretion, and sensitivity are key to glycemic control; an interruption in any part of the insulin process could evolve into Type 2 DM. Most common diabetic complications are due to insulin dysregulations and those complications include diabetic retinopathy, nephropathy, cardiovascular disease, and diabetic neuropathic foot ulcers (Kumar et al., 2010). Medical authorities agree that patient adherence to medical treatment of diabetes prevents debilitating diabetic complications (Kumar et al., 2010; Arifulla et al., 2014). Medication adherence is defined as the degree to which a person with diabetes patient takes prescribed medication as recommended by the attending physician or health care provider (Arifulla et al., 2014).

The World Health Organization (WHO) survey on the global prevalence of DM revealed that the global burden of diabetes was at an all-time high in 2012 (WHO, 2014). Findings from the survey revealed that the worldwide prevalence of DM in 2012 was about 9% among individuals from 18 years of age and above (WHO, 2015). The data also showed that about 1.5 million deaths worldwide were directly related to diabetes in 2012 (WHO, 2015). Diabetes mellitus was projected by the WHO to be the seventh leading cause of death worldwide by the year 2030 (WHO, 2015). The WHO also reported that approximately 80% of diabetes-related deaths occur among individuals who are in low and middle socioeconomic levels (WHO, 2015).

The International Diabetic Federation (IDF) suggested that the number of individuals with DM may rise from about 366 million individuals in 2011 to about 552 million people by the year 2030. The IDF also indicated that about 183 million individuals worldwide who are currently living with diabetes may be unaware of their status (Lysenko & Laakso, 2013). According to Hirst (2013) about 5.1 million deaths worldwide were directly attributed to diabetes mellitus in 2013, with a financial burden estimated at $548 billion in the same year worldwide.

The Center for Disease Control and Prevention (CDC) reported that in the United States about 29.1 million (9.3%) people have diabetes in 2013(CDC, 2016). The prevalence of DM is higher among some racial/ethnic groups than others; American Indians and Alaskan Natives (16.1%) have the highest prevalence of diabetes mellitus followed by non-Hispanic Blacks (12.6%). The group that is least affected by diabetes is non-Hispanic White 7.1%; (American Diabetes Association, 2016).

Comparatively, the prevalence of DM among Jamaicans is as high as the prevalence in the United States and the rest of the world (Ferguson, Tulloch-Reid & Wilks, 2010). The prevalence rates of DM in Jamaica vary according to variables such as age and gender. The prevalence of diabetes mellitus in Jamaica among individuals 15–24 years of age is 1.2% while it is 29.6% among older people aged 65–74 years. Ferguson et al. (2010) indicated that the prevalence of diabetes mellitus among individuals with normal BMI is 4% while it is approximately 13% among individuals who are obese. Ferguson et al. (2010) which is the most current published study on DM in Jamaica also indicated that approximately 9.3% of women have diabetes mellitus as compared to 6.4% of men in Jamaica. A total of 2.8% Jamaicans had impaired fasting glucose which is also known as prediabetes during 2007/2008 survey.

According to Aschner et al. (2016) appropriate medical intervention during the prediabetes period could delay the onset of diabetes. Early diagnosis coupled with adequate intervention and adherence to medical treatment could further prevent the development of diabetic complications. Also, data from the United Kingdom Prospective Diabetes Study (UKPDS) showed that tight glucose control as evidenced by normal HbA1C levels decreased the incidence of diabetic complications. The UKPDS results also showed that after the onset of diabetes, there was a continuous decline in the number of the beta-cells functioning irrespective of the intervention method deployed by an attending physician (UKPDS, 2015). The viability of the beta cells and their functionality continued to regress as patients advanced in age and the number of years after diagnosis increased. Antidiabetic medications are given to help maintain optimal glycemic control

in presence beta cell decline and dysfunction. However, when a patient fails to adhere to the established treatment guidelines, it makes tight glycemic control difficult to achieve (Papadakis et al., 2015). The American Diabetes Association (ADA) recommends several guidelines regarding the treatment and management of diabetic complications. ADA recommends that HbA1c should be controlled at 7.0% or lower. Reducing HbA1C levels 7.0% or less significantly reduces incidences of diabetic complications. After the onset of diabetes, the optimal HbA1C levels can only be achieved through patient adherence to medical treatment regimens. Optimal HbA1C levels can only be achieved after the onset of diabetes through treatment adherence (ADA, 2016). If a patient fails to adhere to prescribed treatment or if a physician fails to adhere to recommended standards of care as outlined by the ADA, diabetic complications for patients become eminent. In the case of Type 1 DM, the beta cells are nonexistent from onset. In Type 2 DM, the beta cells will continue to regress numerically and functionally as diabetes progresses with or without treatment, hence making treatment adjustments and adhering to prescribed treatment the key to preventing diabetic complications (ADA, 2016). Kumar et al. (2010) postulated that irrespective of the fact that there are disparities in the pathophysiology and pathogenesis of various forms of diabetes, most of the complications (microvascular, macrovascular, and neuropathic) accelerate due to nonadherence to antidiabetic medications. Khardori et al. (2015) further suggested that regardless of the type of diabetes, hyperglycemia appeared to be the determinant of microvascular and metabolic complications. Hence medication adherence that prevents hyperglycemia is effective in

decreasing the incidence of diabetic complications and even in enervating the severity of existing complications (Dunn, 2016). Taskaya (2015) suggested that,

> in diabetes management, providing glycemic control plays a main role in care and achieving it depends on the patient adherence to medical treatment faithfully. Therefore, adherence is the extent to which the patient's medication taking behavior corresponded with the prescribed medication regimen (p. 602).

Studies have shown that nonadherence to treatment among people with diabetes prevails across age groups; even young individuals with Type 1 diabetes experience challenges in adhering to recommended treatment regimens (Costa et al., 2015; Cox & Hunt, 2015). Kivimaki et al. (2013) suggested that there is substantial reduction in adherence to medication after individuals enter retirement age; change in socioeconomic status and comorbidities may contribute to the reduction in adherence level among this group. Khardori, et al. (2015) elucidated that the microvascular and macrovascular diabetic complications include cardiovascular disease, diabetic retinopathy (DR), diabetic nephropathy (DN), and diabetic neuropathic foot ulcer.

Diabetic retinopathy (DR)

DR is defined as a major complication of DM that manifests when the blood vessels in the retina are damaged and the blood vessels start leaking blood and other fluids into the retina (American Optometric Association [AOA], 2017). The progressive leak of blood and fluid into the retina causes the retinal tissues to swell, and if left untreated, diabetic retinopathy could cause blindness. Indications of DR include blurred

vision, seeing a dark spot in the center of vision, difficulty seeing well at night, and seeing spots or floaters (AOA, 2017)

According to Khaw, Shah, and Elkington (2010), DR may present as gradual onset of visual loss which is an indication of long duration of uncontrolled hyperglycemia. Diabetic retinopathy (DR) may be classified as mild, moderate, proliferative, or nonproliferative (Bhavsar & Khardori, 2016). Nonproliferative diabetic retinopathy is characterized by micro aneurysm, dot hemorrhage and hard yellow exudates with well-defined edges (Khaw et al., 2010). Macula edema is usually present and may lead to diminished visual acuity. Diabetic maculopathy, also known as diabetic retinopathy at the macula, is the leading cause of blindness in patients with Type 2 diabetes mellitus. The proliferative DR is epitomized by the presence of new blood vessels on the retina that seem to proliferate into the vitreous cavity (Khaw et al., 2010). The new blood vessels are highly susceptible to bleeding, thus resulting in a sudden decrease in vision and production of contractile membranes. The contractile membranes gradually detach the retina which leads to blindness. In some cases, the hemorrhage may lead to occlusion of the drainage angle of the anterior chamber causing rubeotic glaucoma (Khaw et al.., 2010).

Diabetic nephropathy (DN)

Diabetic nephropathy (DN) is a complication that has been diagnosed in individuals living with either Type 1 or Type 2 diabetes mellitus (DM) and typically starts manifesting about 10 to 15 years following onset of DM (Kumar et al., 2010). The pathology of DN is typified by distinct histologic changes that usually occur in the

glomeruli. Findings from studies have shown that diabetic nephropathy is the leading cause of end stage renal disease (Batuman & Khardori, 2016; Kumar et al., 2010). Chronic hyperglycemia coupled with hemodynamic crisis have been identified as triggers of diabetic nephropathy (Batuman & Khardori, 2016). Findings from research have revealed that accumulation of glucose and other metabolites work in synergy with increased vascular permeability to exacerbate extracellular matrix accumulation and proteinuria observed in diabetic nephropathy (Batuman & Khardori, 2016).

Cardiovascular disease

Cardiovascular disease is defined as a syndrome of heart conditions that affect the structure and function of the heart due to persistent hyperglycemia, hyperlipidemia, and elevated levels of amino acids (Fontes-Carvalho, Ladeiras-Lopes, Bettencourt, Leite-Moreira & Azevedo, 2016). Common forms of cardiovascular diseases that are associated with DM include ischemic heart disease, heart failure, and stroke. Acceleration of the atherosclerosis of the aorta, medium size, and larger size arteries is the hallmark of DM. A major complication of atherosclerosis is myocardial infarction (MI) that is localized at the coronary arteries (Kumar et al., 2010). Hyaline arteriolosclerosis, a vascular lesion that is also associated with hypertension is more common and more devastating among people living with diabetes mellitus. Diabetic microangiopathy is another form of cardiovascular disease common among diabetics. The pathology involves diffuse thickening of various basement membranes and selective thickening of the capillaries of the renal medulla, renal glomeruli, retina, skeletal muscles, and the skin. The thickening

of the capillaries is directly responsible for the extensive leaky nature of the cardiac capillaries (Kumar et al. 2010).

Diabetic Neuropathy and Foot Ulcers

Diabetic neuropathy is the most common complication of diabetes mellitus, with about 50% of older patients with Type 2 DM affected (Papadakis et al., 2015). Diabetic neuropathy is classified as peripheral neuropathy (distal symmetric polyneuropathy and isolated peripheral neuropathy) or autonomic neuropathy (Kumar et al., 2010; Papadakis et al., 2015). Other types of diabetic neuropathy include proximal neuropathy and focal neuropathy (WebMD, 2017). The peripheral diabetic neuropathy affects the legs, feet and in some very rare cases affects the arms, abdomen and the back. When peripheral diabetic neuropathy manifests as a distal symmetric polyneuropathy the patient may experience loss of function that appear in a stocking-glove pattern due to an axonal neuropathic process. The axonal neuropathic process involves loss of long nerves that results in motor and sensory conduction delay in peripheral nerve and even absence of ankle jerks (Papadakis et al., 2015).

> Sensory involvement usually occurs first and is in general bilateral, symmetric and associated with dulled perception of vibration, pain and temperature the denervation of the small muscles of the foot results in clawing of the toes and displacement of fat pad (Papadakis et al., 2015, p.1215).

The complex changes that occur in the foot because of diabetic neuropathy result in the alteration of the foot biomechanics. Extensive biomechanical variations in the foot promotes high pressure areas that rupture and become ulcerated, and such areas have

been implicated in most diabetic foot deformities (WebMD, 2017). Diabetic neuropathic foot ulcer consists of wounds that occurs because of compromised vasculatures due to poor perfusion. Diabetic neuropathic foot ulcers can be triggered by injury and/or infections in the high-pressure areas (Papadakis et al., 2015). Kumar et al. (2010) indicates that the pathogenesis of diabetic foot ulcer is typified by inadequate circulation to the lower extremities coupled with microvascular disease, in association with diminished sensation due to neuropathy. Infections of diabetic foot ulcer are major triggers of a span of broad spectrum of complication pathology ranging from superficial cellulitis to osteomyelitis.

Diabetes mellitus is a complex metabolic syndrome that could trigger several types of complications such as diabetic retinopathy (DR), diabetic nephropathy (DN), cardiovascular disease and diabetic neuropathic foot ulcers. However, when patients and attending physicians adhere to recommended standards of care for diabetes, the risk of these complications for individuals declines to a bearable minimum (ADA, 2016). On the other hand, patient nonadherence to diabetic treatment exacerbates the excruciating problems that are linked to diabetes (ADA, 2016).

Problem Statement

According to Amado et al. (2015) nonadherence to physician- recommended therapeutics among people with diabetes is a global problem that deserves more attention. Kivimäki et al. (2013) argued that while antidiabetic medications have been shown to be effective in decreasing diabetic complications, patient nonadherence to taking medication is common, and the resultant diabetic complications are on the rise. Contreras et al.

(2011) reported that 25% of people with diabetes who participated in their study were therapeutically nonadherent. Amado et al. (2015) suggested that nonadherence to treatment plan compromises patient's opportunity to achieve optimal glycemic control. Khan et al. (2012) argue that when the health seeking behaviors of a people with diabetes lack congruence with recommendations of a health care provider, the result is usually diabetic complications.

Jamaica has a high prevalence of Type 1 and Type 2 diabetes mellitus (DM). According to the 2007/8 Jamaica Health and Life Style (JHLS) Survey, 7.9% of the population of Jamaica had DM and additional 2.8% of the population was living with impaired fasting glucose. Ferguson, Tulloch-Reid, and Wilks (2010) stated that there are only few published studies regarding adherence to diabetic medication treatment plans and diabetic complications in Jamaica and the Caribbean region. As a result, there is a gap in the literature regarding the relationships between levels of adherence to medical treatment and complications from diabetes in Jamaica.

Purpose of Study

In this quantitative, correlational study, I explored the relationship between levels of adherence to antidiabetic medications, HbA1c levels and diabetic complications (cardiovascular disease, diabetic retinopathy, diabetic nephropathy, diabetic neuropathic foot ulcer). This study revealed that levels of adherence to antidiabetic medication negatively correlates with diabetic complications while HbA1c levels positively correlates with diabetic complications. The outcome of this study may be key to creating

needed awareness and possibly encourage other researchers to help conduct more extensive study in this area.

Research Questions and Hypotheses

I examined the predictive relationships between patient level of adherence to therapeutic regimens (physician prescribed diabetic medication), HbA1c levels and diabetic complications. Levels of adherence to treatment and HbA1c were the independent variable while diabetic complications such as cardiovascular disease, retinopathy, nephropathy and neuropathic foot ulcer are the dependent variables. The control variables include age and gender.

Research Question 1 (RQ1): How well do patient adherence to antidiabetic medication and HbA1c levels (glycemic control) predict the severity of retinopathy among people with diabetes in Jamaica after controlling for age and gender?

Null Hypothesis ($H_0$1): Patient adherence to antidiabetic medication (Morisky 8-item Adherence Scale) and HbA1c levels (glycemic control) are not statistically significant predictors of the severity of retinopathy among people with diabetes in Jamaica, after controlling for age and gender.

Alternative Hypothesis (H_a1): Patient adherence to antidiabetic medication (Morisky 8-item Adherence Scale) and HbA1c levels are statistically significant predictors of the severity of retinopathy among diabetic patients in Jamaica, after controlling for age and gender.

Research Question 2 (RQ2): How well do patient adherence to antidiabetic medication and HbA1c levels (glycemic control) predict the severity of nephropathy among people with diabetes in Jamaica, after controlling for age and gender?

Null Hypothesis (H_02): Patient adherence to antidiabetic medication (Morisky 8-item Adherence Scale) and HbA1c levels are not statistically significant predictors of the severity of nephropathy among people with diabetes in Jamaica, after controlling for age and gender.

Alternative Hypothesis (*Ha2*): Patient adherence to antidiabetic medication (Morisky 8-item Adherence Scale) and HbA1c levels are statistically significant predictors of the severity of nephropathy among people with diabetes patients in Jamaica, after controlling for age and gender.

Research Question 3 (RQ3): How well do patient adherence to antidiabetic medication and HbA1c levels predict the severity of cardiovascular disease among people with diabetes in Jamaica, after controlling for age and gender?

Null Hypothesis (H_03): Patient adherence to antidiabetic medication (Morisky 8-item Adherence Scale) and HbA1c levels are not statistically significant predictors of the severity of cardiovascular disease among people with diabetes in Jamaica, after controlling for age and gender.

Alternative Hypothesis (Ha3): Patient adherence to antidiabetic medication (Morisky 8-item Adherence Scale) and HbA1c levels are statistically significant predictors of the severity of cardiovascular disease among people with diabetes patients in Jamaica, after controlling for age and gender.

Research Question 4 (RQ4): How well do patient adherence to antidiabetic medication and HbA1c levels predict the severity of neuropathic foot ulcer among people with diabetes in Jamaica, after controlling for age and gender?

Null Hypothesis ($H_0$4): Patient adherence to antidiabetic medication (Morisky 8-item Adherence Scale) and HbA1c levels are not statistically significant predictors of the severity of neuropathic foot ulcer among people with diabetes patients in Jamaica, after controlling for age and gender.

Alternative Hypothesis (H_a4): Patient adherence to antidiabetic medication (Morisky 8-item Adherence Scale) and HbA1c levels are statistically significant predictors of the severity of neuropathic foot ulcer among people with diabetes patients in Jamaica, after controlling for age and gender.

The independent variables in this study were levels of adherence to recommended Antidiabetic medications determined by responses from Morisky 8-item Adherence Scale and HbA1C levels. The dependent variables were cardiovascular disease, retinopathy, nephropathy, and diabetic neuropathic foot ulcers.

Theoretical framework

Nonadherence to prescribed treatment could be viewed as a cognitive self-regulated behavior that could be predicted in accordance to the theory of planned behavior (Janzen, 1985). The theory of planned behavior was proposed by Icek Ajzen in 1985 in an article captioned "From intentions to actions: the theory of planned behavior" (Ajzen, 1985). The theory is an extension of the theory of the reasoned action which addresses the challenges of incomplete volitional control (Van Camp, Bastiaens, Van

Royen, & Vermeire, 2016). The theory of planned behavior suggests that human behavior is guided by the following three conceptual elements: (a) beliefs about the likely consequences of behavior (behavioral beliefs), (b) normative beliefs or the notion that expectations of other people influence a person's behaviors and (c) volitional control, or beliefs which indicate that an individual can decide at will to perform or not perform a behavior (Ajzen, 1985). The fundamental principle of planned behavior theory is that behavioral beliefs or attitudes towards treatment plan translate into a healthy or unhealthy behavior, and that such behavior is predictable (Ajzen, 1985).

The theory of planned behavior explicates that behavioral intentions is a major determinant of behavior because people seem to consider the implications of their actions before engaging or refraining in diverse kinds of behaviors. A person's intentions, coupled with perceptions of behavioral control contribute to variance in actual behavior (Sharma & Romas, 2012). Sharma and Romas (2012) posited that past behaviors could be used to make prediction about future behavior. Findings from several studies have shown that the theory of planned behavior has been quite useful in making predictions about future behaviors (Sharma & Romas, 2012).

Nature of Study

In this quantitative, correlational study, I examined the predictive relationships between levels of adherence to antidiabetic medication, HbA1c and diabetic complications among diabetics in Jamaica. I used the cross-sectional design for this study. The cross-sectional design is one of the most commonly used research designs in health promotion and hence the most appropriate design for this study. In cross-sectional

design the data are usually collected at one point hence the time is fixed, and therefore it is considered the hallmark of this study design (Creswell, 2014).

Definitions

Definitions are presented to clarify terms used in this study and to assist readers to understand why such terms were use; these terms are listed below.

Diabetes Mellitus: Khardori et al. (2015) defined diabetes mellitus as a chronic metabolic disorder characterized by a combination of insulin resistance at the peripheral level and inadequate insulin secretion by the beta cells in the pancreas or absence of insulin caused by autoimmune destruction of the beta cells.

Medication adherence: Hugtenburg et al. (2013) defines medication adherence as the degree to which an individual is able conform to a physician's prescribed treatment regimens (80% -100%).

Medication nonadherence: Medication nonadherence is a diagnosable and treatable medical condition that could deprive a patient the opportunity to recover or the ability to mitigate the complications of disease (Marcum et al., 2013). Nonadherence is determined when a patient takes medication less than 80% of the recommendation.

Diabetic retinopathy (DR): Diabetic retinopathy (DR) is defined as a major complication of inadequately controlled diabetes mellitus that manifests when the blood vessels in the retina are damaged (Kapadakis, 2015).

Diabetic nephropathy (DN): Diabetic nephropathy is a complication that is characterized by persistent microalbuminuria, progressive decline in glomerular filtration rate (GFR) and elevated arterial blood pressure (Kumar, Abbas & Fausto, 2010).

Cardiovascular disease: Cardiovascular disease is defined as a syndrome of heart conditions that affect both the structure and function of the heart due to persistent hyperglycemia, hyperlipidemia and elevated levels of amino acids (Fontes-Carvalho, Ladeiras-Lopes, Bettencourt, Leite-Moreira & Azevedo, 2016).

Diabetic neuropathic foot ulcer:. Diabetic neuropathic foot ulcers are wounds that occur because of compromised vasculatures that results into inadequate perfusion via the microcirculatory network (Kumar, Abbas & Fausto, 2010).

Assumptions

There are several assumptions associated with this research. It was my assumption that the archived data, the information and the variables in the database were complete, accurate and that the hospital collected them using interviewer administered Morisky 8-item Adherence Scale and laboratory results of HbA1c of all the participants. It was my assumption that the respondents were honest and that inability to recall frequency of nonadherence did not affect the overall data. I assumed that other factors such as physical inactivity, diet, genetics and socioeconomic status do not contribute to the development of diabetic complications. I assumed normal distribution of the dependent (y) variable which are the diabetic complications and that there was linear relationship between x (independent variable) and y (dependent variable). I also assumed independent observations and homoscedasticity of the data collected (Grove & Cipher, 2017).

Scope and Delimitations of Study

I examined predictive relationship between patient adherence to antidiabetic medications and diabetic complications. Adherence to antidiabetic medication

determined by HbA1c levels and patient responses from Morisky-8 scale were the independent variables. The dependent variables were the following diabetic complications: cardiovascular disease, retinopathy, nephropathy and diabetic neuropathic foot ulcer. Age and gender were the control variables. It was beyond the scope of this study to address other mitigating factors that may contribute to the onset or prognosis of diabetic complications. In addition, diabetic complications such as diabetic ketoacidosis, hyperosmolar hyperglycemic state, diabetic enteropathy, diabetic peripheral neuropathy are the delimitations of this study.

Limitations of Study

A major limitation of this study was that there are many other factors such as sedentary lifestyle, smoking cigarettes, obesogenic diet options, advanced age, late or un-diagnosed diabetes mellitus, use of complementary or alternative medicines and even co-morbidities that could contribute to the manifestations of diabetic complications (Gemeay et al., 2015). The afore mentioned variables could also exacerbate the diabetic complications (Papadiski, 2015).

Another limitation was that I used secondary data which might not be a true representation of the Jamaican society. The sample size used for this study was 119 and could be a constraint on the generalizability of this study. Responses to the Morisky 8-item Adherence Scale questionnaire were self-reported and subjected to selective memory, telescoping, attribution and/or exaggeration (Brutus et al., 2012). Lack of prior studies on this topic in the Caribbean in recent years to reference as empirical data was also a limitation to this study.

Significance of Study

Ferguson et al. (2010) indicated that a study on nonadherence to therapeutic regimens among Jamaican diabetics has never been done, and only very few studies of this nature have been conducted in Jamaica. Ferguson et al. (2010) also indicated that there are only few published data regarding diabetic complications in Jamaica and Caribbean region. The authors argue that such data will be helpful in planning effective strategies to combat diabetes mellitus. Hence it is essential to know whether the diabetic complications that are diagnosed among this population correlates with nonadherence to the recommended therapeutics. The potential positive social change impact of this study will be to inform other public health professionals to create public awareness about the consequences of patient nonadherence to medical treatment for diabetes.

The information from this study would provide empirical evidence of the link between patient adherence or nonadherence to diabetic medication and diabetic complications among Jamaicans diagnosed with diabetes. Social workers and other health care professionals could use the information to advocate for specific interventions that focus on improving patient adherence to prescribed medications. Those interventions would then be a major step toward combating the epidemic of diabetic complications. An additional social change outcome would be improving the health outcomes for diabetic patients in Jamaica.

Summary

Diabetes mellitus is a chronic metabolic disorder that has become a global epidemic that leads to serious health implications (Shivashankar et al., 2016). The 2014

National Diabetes Statistics report indicates that 29.1 million individuals or 9.3 percent of American population is living with diabetes mellitus while only 21 million people are diagnosed with the disease, and 8.1 million undiagnosed (CDC, 2016). The burden of diabetes in many societies including Jamaica is great, but results of many studies have shown that adherence to recommended treatment has been effective in slowing down the progress of the disease and preventing diabetic complications (ADA, 2016).

Diabetes treatment demands active involvement of the patients. However, nonadherence to physicians prescribed therapeutic regimen is the greatest challenge in the effective treatment of diabetic patients worldwide and has become a growing concern for all health care providers (Remington et al., 2010). Accumulation of scientific evidence points to the fact that nonadherence to prescribed medication is responsible for the numerous diabetic complications that have become prevalent among diabetic patients (Remington et al., 2010; Kumar et al., 2010). Results from empirical studies have shown that adherence to recommended antidiabetic drugs helps to achieve tight glycemic control. Adherence to antidiabetic medications also helps to decrease systemic, glomerular hypertension, inflammatory process and prevents metabolic syndrome (Kumar et al., 2010; Papadakis et al., 2015). In this quantitative study, I examined the predictive relationships between adherence to medical treatment for diabetes, HbA1c levels and diabetic complications among diabetics in Jamaica. I used the cross-sectional design for this study. The data was collected at one point, hence the time is fixed and considered the hallmark of this study design (Creswell, 2014).

In chapter 2, I will review current literature on nonadherence to antidiabetic medications and diabetic complications. Findings from studies have revealed that nonadherence to antidiabetic medications may be associated with various diabetic complications. I will start the chapter with a preface of nonadherence to antidiabetic medications and progress to literature search strategy, theoretical foundation and framework, review of key variables, risk factors and epidemiology of diabetes and nonadherence.

Chapter 2: Literature Review

Introduction

Patient nonadherence is defined as a patient's failure to adhere to a prescribed course treatment by the attending physician (MedicineNet, 2018). Nonadherence to physician prescribed antidiabetic medication is a complex and multidimensional problem (Hugtenburg et al., 2013). According to Hugtenburg et al. (2013), diabetic patient nonadherence to treatment can consist of any of the following actions: (a) patient refusal to fill or refill medication prescriptions in a timely manner which results in failure to commence treatment or a gap during the period of treatment, (b) patient using more medications or less medications than what is prescribed by a physician, and (c) patient deviating from the doctor prescribed schedule for taking medications. Irrespective of the reason for patient nonadherence, a major consequence of nonadherence is that the individual will not be able to obtain an optimal pharmacotherapeutic benefit; consequently, the individual faces increased diabetic complications (Hugtenburg, 2013).

Studies have shown that antidiabetic medications are essential in preventing the complications of diabetes mellitus (Blackburn, Swidrovich & Lemstra, 2013; Hugtenburg, 2013). Diabetic complications associated with medication nonadherence have been attributed to increased mortality among people with diabetes and have caused unbearable healthcare cost burdens to many countries (Blackburn et al., 2013). Nonadherence to antidiabetic medication is a serious public health challenge and has become a priority for governments and healthcare providers around the globe. According to Blackburn et al. (2013), factors such as concurrent chronic use of multiple medications

to treat numerous comorbidities, advancing age, socioeconomic factors, gender, and even fear of side effects of antidiabetic medications all contribute to nonadherence. Nonadherence to medication among diabetic patients is high and even alarming when compared to other conditions, and it is inextricably linked to multiple hospitalizations and diabetic complications (Blackburn et al., 2013).

The purpose of this study was to explore any correlations between nonadherence (low levels of adherence and high levels of HbA1c) and diabetic complications (cardiovascular disease, diabetic retinopathy, diabetic nephropathy, and neuropathic diabetic foot ulcers). In this chapter I will cover the strategies that I used in the search of literature, the theoretical foundation, and the framework of this study. I will also review related current literature on the association of nonadherence to antidiabetic medication with cardiovascular diseases, diabetic retinopathy, diabetic nephropathy, and diabetic neuropathic foot ulcer.

Literature Search Strategy

I conducted an extensive search of relevant literature digitally through electronic medical and public health databases such as MEDLINE, CINAHL, American Diabetes Association (ADA), Medscape, Univadis, New England Journal of Medicine as well as through Walden University library database. I used search terms such as *diabetes mellitus Type 1, diabetes mellitus Type 2, diabetic complications, retinopathy, nephropathy, cardiomyopathy,* and *diabetic foot* to conduct the literature search. I obtained other sources and articles for this literature review traditionally through printed versions of professional journals such as the Journal of American Pathologists, as well as numerous

medical books on pathologic basis of disease, public health epidemiology and environmental health. All books, journals, and electronic print materials used in this study were published within the last 6 to 7 years.

Theoretical Foundation

I used the theory of planned behavior as the theoretical framework for this study. According to Ajzen (1985), the theory of planned behavior explicates that human actions are guided by three major considerations which include: a) beliefs regarding the likely outcomes of a behavior and the evaluations of the belief's outcomes; b) normative beliefs, which are expectations of others and motivation to conform with these expectations; and c) control beliefs, which states that the presence of influencing factors may enable or hinder manifestation of a behavior. When attitude towards behavior is combined with subjective norm coupled with perception of behavioral control, it results in the development of a behavioral intention (Rich, Brandes, Mullan, & Hagger, 2015). The theory of planned behavior has proven to be useful in predicting behavior such as adherence. Levels of adherence could be predicted based on consistent forms of attitude, subjective norm, perceived behavioral control, intention and previous behaviors (Rich et al., 2015).

According to Van Camp et al. (2016), planned behavior could potentiate satisfactory or unsatisfactory behaviors, good or bad intentions, positive life-changing attitudes, or negative self-destructive attitudes that could translate to variance in actions. According to Sharma and Romas (2012), studies have shown that people seem to consider the implications of their action before engaging or refraining from various kinds

of behaviors. Nonadherent behaviors could be predicted with a high degree of accuracy by closely examining patient's attitudes toward medical treatment, their perceived behavioral control and subjective norms. When a patient has a sufficient behavioral control coupled with good intentions the patient is most likely go to adhere to treatment regime (Sharma & Romas, 2012).

Literature Review Related to Key Variables

Diabetes mellitus (DM)

DM is defined as a chronic metabolic syndrome that is characterized by hyperglycemia, hyperlipidemia, and elevated amino acids (Kumar et al., 2010). Kaul, Tarr, Ahmad, and Chibber (2013) suggested that diabetes mellitus is a chronic debilitating metabolic disease that has tremendous health consequences. Diabetes mellitus compromises the immune system, promotes retinopathy, nephropathy, neuropathy (somatic and autonomic), and cardiovascular diseases. Khardori et al. (2015) defined diabetes mellitus as chronic metabolic disorder that has been classified as Type 1 and Type 2. According to Khardori et al. (2015), Type 1 diabetes mellitus is a chronic disease that affects multiple organs and the nervous system. Type 1 diabetes affects the metabolism of carbohydrate, fat, and protein due to the absence of insulin caused by autoimmune destruction of the beta cells which translates to metabolic catastrophe unless it is adequately managed. Type 1 diabetes mellitus can occur at any age, but it is more common among juveniles; however, adults in their late 30s and early 40s have been diagnosed of Type 1 diabetes mellitus.

Type 2 diabetes is characterized by a combination of insulin resistance at the peripheral level and inadequate insulin secretion by the beta cells in the pancreas. According to Khardori et al. (2015) insulin resistance is a major complication of sustained elevated levels of free fatty acids and pro-inflammatory cytokines in the plasma, which decreases glucose transport into muscle cells and results in elevated hepatic glucose production. Patients living with Type 2 DM do not unequivocally depend on insulin for life; however, they may need insulin as the disease progresses and or when the pancreas completely fails to secret insulin (Kumar et al., 2010).

Type 2 diabetes mellitus was originally considered adult-onset diabetes but findings from studies have shown that the epidemic of obesity coupled with sedentariness among children in certain populations has resulted in Type 2 DM (CDC, 2016; Kumar et al., 2010). However, individuals who are 40 years and older who have a family history of DM are at greater risk for Type 2 DM (ADA, 2016). Empirical data show that Type 2 diabetes increases the risk of coronary heart disease (CHD) in women more than in men (ADA, 2016).

Papadakis and McPhee (2015) maintained that diabetes mellitus is a metabolic syndrome that is characterized by hyperglycemia due to malfunction of the pancreatic islet cells that translates to paucities of insulin secretion and or insulin resistance. Kumar et al. (2010) argued that diabetes mellitus is more than a disease as it presents with a group of synchronized metabolic maladies that share a common denominator, which is hyperglycemia. Results from studies have shown that sustained hyperglycemia translates into myriad of organ related complications and even further metabolic dysregulations.

Insulin is a metabolic hormone that is essential and indispensable; deficiency or absence of insulin secretion that is left untreated or uncontrolled results in various forms of diabetic complications.

> Report from Diabetes complications and control Trial (DCCT) revealed that "a near normalization of blood glucose resulted in a delay in the onset of diabetes. Data in the same study showed that normalization of blood glucose contributed to a major slowing of the progression of established microvascular and neuropathic diabetic complications" (p. 1192).

Results from the study highlights the fact that adhering to recommended therapeutics could be successful in preventing diabetic complications (Papadakis et al., 2015).

Patient Nonadherence and Diabetic Complications

According to Chang, Chien, Lin, Chiou, and Chiu (2015) patient nonadherence to antidiabetic treatment translates to poor glycemic control which has been associated with end-stage renal disease (ESRD) among diabetics. Chang et al. (2015) explored the correlations between antidiabetic medication nonadherence and the risk of developing ESRD among patients who were newly diagnosed with diabetes mellitus. They extracted archived data from the Taiwan National Health Insurance Research Database (NHIRD) and identified 559,864 records that met the inclusion criteria for the data analysis. The records that met the criteria for the study belonged to individuals between the ages of 20 to 85 years during the study. Chang et al. (2015) indicated that records show that 16695 patients developed end stage renal disease (ESRD) during the 6-year study period. The

researchers found that patients who did not adhere to antidiabetic medication therapy had higher risk of developing ESRD when compared to patients who adhered to antidiabetic medication therapy. The outcome of the study also revealed that adherence to antidiabetic medication could prevent the acceleration of the loss of renal function and even ESRD among diabetic patients.

According to Busko (2014), nonadherence to antidiabetic medication results in sustained hyperglycemia which has long term effect on the microvasculature and most major organs. Living with either Type 1 or Type 2 diabetes for more than 10 years has been associated with microvascular and macrovascular complications such as cardiomyopathies, nephropathy, or even retinopathies. These recent findings provide a unique opportunity to health care providers to refocus efforts towards intense or aggressive management of hyperglycemia from the time of diagnosis of diabetes among younger population to minimize the risk of long-term complications.

Variables Related to Adherence to Medication

Kirkman et al. (2015) conducted a retrospective study analysis of records obtained from a pharmacy claims database examining patients, types of medication, and their prescribers to determine a range of factors that may have influenced adherence to the prescribed antidiabetic medications. They analyzed more than 200,000 patients records of individuals who received treatment for diabetes mellitus with oral antidiabetic medications in 2010 (Kirkman, 2015). The outcome of the study revealed that adherence to medication was correlated with older age, being a man, higher levels of education, higher income, method of delivery of medication, and lower copay for medications. Data

from the study showed that newly diagnosed diabetic patients perceived to be healthy with no comorbid conditions and who were taking few medications were at greater risk for nonadherence to antidiabetic medication than the older population with multiple comorbid conditions (Kirkman, 2015).

In a secondary data analysis of medical records and questionnaires obtained from 1369 diabetic patients, Billimek et al. (2014) found that gender disparities in nonadherence to medications was responsible for differences observed in lipid management among individuals living with Type 2 diabetes mellitus. The outcome of the same study also indicated that the level of nonadherence among women living with diabetes was associated with the side effects of the medications in question, in addition to the cost of the medication. They concluded that even though the quality of diabetic care given to both men and women was comparable, women living with diabetes presented with poor lipid control more frequently than men living with diabetes mellitus (Billimek et al., 2014).

Busko (2014) suggested that patients who are diagnosed with Type 2 DM at a relatively younger ages were more susceptible to diabetic complications as they get older, due to nonadherence over time. Busko (2014) also suggested that older patients living with Type 2 diabetes for a longer time coupled with nonadherence have shown to be at an increased risk of having cardiovascular events such as cardiovascular myopathies, fatal or nonfatal myocardial infarction, or fatal or nonfatal stroke.

Rosengren et al. (2015) conducted a cohort study involving 33402 participants who had DM for an average of 20 years and were followed for about 8 years. The

outcome of the study revealed that the percentage of participants admitted to the hospital due to heart failure increased as their age and the duration of diabetes increased. Findings from the study also showed that uncontrolled hyperglycemia increased the risk of heart failure and albuminuria among the population. In addition, the study revealed that participants that had Type 1 diabetes had a four times increased risk of being hospitalized due to heart failure, when compared with the general population.

Khardori et al. (2015) argued that cardiovascular myopathies among people living with diabetes is common because it is related in part to nonadherence to antidiabetic medication which promotes elevated levels of low-density lipoprotein (LDL), low levels of high-density lipoprotein (HDL), high levels of triglyceride-rich remnant lipoproteins, thrombotic abnormalities such as high levels of type-1 plasminogen activator inhibitor (PAI-1), and elevated levels of fibrinogen.

There are obvious disparities in the burden of DM among various populations in the United States and the world. According to the CDC (2016), African Americans and Hispanic Americans have been disproportionately affected by diabetes mellitus more so than any other group in the United States. According to Ogden, Carroll, Kit, and Flegal (2013) data from the National Health and Nutrition Examination Survey from 2011–2012 show that more than one-third (34.9%) of American adults were obese in 2011–2012. The survey also showed that obesity was higher among middle-aged adults (39.5%) than among younger (30.3%) or older (35.4%) adults. There were no disparities between men and women during same period. However, overall among non-Hispanic Black adults, 56.6% of women were obese compared with 37.1% of men (Ogden et al. 2013). Obesity

in the United States was more prevalent among non-Hispanic Black (47.8%) followed by Hispanic (42.5%), non-Hispanic white (32.6%) and less prevalent among non-Hispanic Asian adults (10.8%) (Ogden et al., 2013). Studies have shown that obesity or being overweight is a major reason for the alarming prevalence of Type 2 diabetes (WebMD, 2016).

Risk Factors

The risk factors for Type 1 DM include family history (mother, father, or sibling) with Type 1 diabetes, being of Northern European ancestry, genetic factors such as positive human leucocyte antigen (HLA-DR3, DR4 and DQ), and environmental factors (WebMD, 2016; Medscape, 2018). The risk factors for Type 2 diabetes include first degree relative with DM, obesity or being overweight, impaired glucose tolerance, insulin resistance, race (African American, Hispanic, and American Indian). Polygenic components such as high blood pressure, low levels of high-density lipoprotein (HDL), and high levels of triglycerides, gestational diabetes, sedentary lifestyle, polycystic ovary syndrome, and advancing age greater than 45 years increases the risk of Type 2 DM (WebMD, 2016; Medscape, 2018).

According to the Dunn et al. (2014) autoimmune reaction triggered by an infection such as Coxsackie B virus in a genetically susceptible individual is related to the etiology of Type 1 diabetes mellitus. The pathogenesis involves lymphocytic inflammation of the islet of Langerhans (insulitis) that leads to loss of B-cells and fibrosis of the islets (Kumar et al., 2010). Subsequently, defects in the translation of the insulin RNA occurs in the ribosomes attached to the rough endoplasmic reticulum (RER). The

RER is the location where insulin preprohormone is formed. The insulin preprohormone are subsequently cleaved to produce proinsulin which are further cleaved in the Golgi apparatus producing insulin and peptide fragments. Inability to synthesize insulin is a classical pathology associated with Type 1 DM. Insulin synthesis abnormality seen in Type 1 DM has been associated to genetic abnormality and exposure to environmental factors such as early childhood infection (Dunn, et al., 2014).

Studies have shown that being overweight or obesity is a risk factor for Type 2 DM because such individuals may have increased insulin resistance (Kumar et al., 2010; Remington et al., 2010; Khardori et al., 2015). Obesity or being overweight adds an undue stress to the beta cells of the pancreas. Obese individuals eat more to meet their bodies energy demands, and overeating stresses the membranous network in the cells particularly endoplasmic reticulum. Results obtained from studies have shown that when the endoplasmic reticulum has metabolic product overload it sends a negative feedback, signaling the cell to dampen the insulin receptors on the cell surface. Sustained dampening of the insulin receptors due to persistent hyperglycemia translates in to insulin resistance (Medicinenet, 2018). Type 2 DM develops only in individuals who cannot adequately compensate for their insulin demand due to their insulin resistance; their insulin concentration is usually elevated, yet inadequate for tight glycemic control (Kaplan et al., 2017). Sedentary behaviors and elevated body mass index (BMI) increase the risks of diabetes, and other chronic diseases (Remington et al., 2010). According to the WHO (2018) a sedentary lifestyle increases the risk of cardiovascular diseases, diabetes, and obesity. When physical inactivity combines with nonadherence to

prescribed antidiabetic medications, the synergistic effect accelerates diabetic complication among diabetics (Medscape, 2018). Rosengren et al. (2015) suggested that inadequate glycemic control coupled with sedentary behavior tremendously increased the risk of cardiac abnormalities among diabetics.

Nonadherence to Medications Among Jamaicans

Result from the 2007/8 Jamaica Health and Life Style Survey (JHLS) of individuals between the age of 15 to 74 years of age, revealed that about 7.9% of the population of were living with DM, while 2.8% had impaired fasting glucose also known as prediabetes (Ferguson et al., 2010). The same study elucidates that comorbid conditions were common among the target population. About 10.7% of the diabetic population reported they had one comorbid condition, with 22.3% reporting two comorbid conditions, while 63.2% reported that they had three or more comorbid conditions. Only 3.8% of the diabetics reported no comorbid conditions (Wilks et al., 2009). In addition, data from the survey showed that only 43.9% of diabetics in Jamaica had tight glycemic control, while 52.6% reported uncontrolled diabetes. This finding highlights an alarming prevalence of nonadherence to antidiabetic treatment in Jamaica. Wilks et al. (2009) also reported that results from the 2007/8 JHLS revealed that only 40% of diabetics in Jamaica adhered to their antidiabetic medication, while 60% were non-adherent.

Common reasons for nonadherence among this target population included inability to afford medication (7%), sense of feeling better (3.3%), side effects of the medications (3.0%), hearing other people complain of side effects (1.4%), forgetfulness

(11%), individuals running out of medication before next appointment (9.0%), and some diabetics could not bother taking the medications as prescribed (7.0%) (Wilks et al., 2009). The epidemiology of nonadherence to antidiabetic medication is real and the alarming incidence of diabetic complications among this target population seem to correlate with the level of nonadherence to antidiabetic medication therapy.

According to 2007/8 Jamaica Health and Life Style Survey (JHLS) interventions to prevent nonadherence to antidiabetic medications should be tailored to the specific needs of each patient since it is obvious that there are different causes of nonadherence (Hugtenburg, 2013). Preventive measures implemented at the primary level, secondary level, and tertiary level coupled with many factors working synergistically may be the antidote to combat nonadherence to antidiabetic medications that translates into diabetic complications (ADA, 2016). It is a known fact that lack of access to good quality healthcare may be partly responsible for the alarming rate of nonadherence to antidiabetic medications in resource poor countries like Jamaica (Rosennberg, 2011). Hence, if the government of Jamaica is serious about reducing diabetic complications, they must guarantee access to a well-funded healthcare system for all its citizens.

According to the Ministry of Health (2015) the Jamaican government guarantees access to public hospitals for all its citizens. However, the healthcare system is grossly underfunded and severely underserved, hence best medical practices are constantly in jeopardy. The long wait time discourages patients from attending scheduled visits, and as a result, many patients run out of antidiabetic medications. Some diabetics stay home, and only seek care when they start experiencing severe complications (The Jamaican

Gleaner, 2014). Addressing the challenges that diabetics face while trying to access the healthcare system is an important preventive measure that cannot be over stated.

Adverse Outcome of Nonadherence to Treatment for Diabetes

Living with either Type 1 or Type 2 diabetes for more than 10 years has been associated with microvascular and macrovascular complications such as cardiomyopathies, nephropathy, retinopathies and neuropathic foot ulcer (Busko, 2014). Atrophy of the pancreas is a diabetic complication that develops because of prolonged and uncontrolled hyperglycemic state (Kumar et al., 2010).

Cardiovascular Disease

Rosengren et al. (2015) conducted a cohort study with 33,402 participants to determine the effect of uncontrolled hyperglycemia. The mean age of the patients was 35 years with standard deviation (SD) of 14. 45 years. The participants had diabetes for an average of 20.1 years [SD 14·5]). The researchers followed participants for about 8 years. They found that uncontrolled hyperglycemic state translated into increased risk of heart failure and albuminuria for diabetic patients. Result from the study show that 1062 (3%) of the participants were admitted to the hospital following heart failure. The percentage of heart failure increased as the patient advanced in age, and as the duration of diabetes increased. Participants with Type 1 diabetes had four times increase in the risk of being hospitalized due to heart failure, when compared with the general population.

Papadakis et al. (2015) argued that cardiovascular myopathies among people living with diabetes has being associated to insulin resistance or lack of insulin synthesis. Khardori et al. (2015) indicates that the dysfunction of insulin or lack of insulin synthesis

coupled with nonadherence to medical treatment amplifies low-density lipoprotein (LDL), triglyceride-rich remnant lipoproteins, type-1 plasminogen activator inhibitor (PAI-1), fibrinogen and suppresses high-density lipoprotein (HDL). Khardori et al. (2015) also reported that microvascular and macrovascular DM complications include cardiovascular disease, which occurs subsequent to concomitant lipid abnormalities such as elevated levels of low-density lipoprotein (LDL), decreased levels of high-density lipoprotein (HDL) and high levels of triglyceride. There are also thrombotic complications such as high type-1 plasminogen activator inhibitor (PAI-1) and elevated fibrinogen.

Diabetic Retinopathy

There are two categories of diabetic retinopathy: proliferative and nonproliferative retinopathies. The nonproliferative retinopathy is the early stage of the retina involvement and it is characterized by the presence of microaneurysms, dot hemorrhages, exudates and retinal edema in-addition to macular edema. During the nonproliferative stage, the integrity of retinal capillaries is compromised resulting in leaking of proteins, lipids, and red blood cells into the retina. When macular edema occurs, the functionalities of the visual cells are hampered resulting in the interference with visual acuity, hence visual impairment. Proliferative retinopathy is more common in Type 1 diabetes mellitus than Type 2 and involves the growth of new capillaries within the retina. Proliferative retinopathy develops due to prolonged small vessel occlusion that cause hypoxia within the retina (Papadakis et al., 2015).

Diabetic Nephropathy

Diabetic nephropathy is caused by persistent hyperglycemia that cause hyperfiltration, glycation of metabolites, activation of cytokines, and subsequent renal injury (Medscape, 2017). Diabetic nephropathy presents like an autoimmune disorder that has an overlapping pathophysiology of innate immunity and regulatory T-cells activities in both Type 1 and Type 2 diabetes (Medscape, 2017; Papadakis et al., 2015). Elevated blood glucose and saturated fatty acids levels create an inflammatory medium, which results in activation of the innate immune system, thereby activating the nuclear transcription factors-kappa B (NF-κB), and subsequent release of inflammatory mediators such as interleukin (IL)–1β and tumor necrosis factor (TNF)–α. This promotes systemic insulin resistance and β-cell damage due to autoimmune insulitis. Elevated serum glucose and free fatty acids levels, and IL-1 causes glucotoxicity, lipotoxicity, and IL-1 toxicity, which culminates in apoptotic β-cell death. Hyperglycemia increases the expression of transforming growth factor-β (TGF-β) in the glomeruli and of matrix proteins, that are directly stimulated by this cytokine. TGF-β and vascular endothelial growth factor (VEGF) are likely to be instrumental in cellular hypertrophy and enhanced collagen synthesis, thereby inducing the vascular often displayed in diabetic nephropathy (Medscape, 2017).

Diabetic Neuropathic Foot Ulcer

Diabetic neuropathic foot ulcer is common among diabetic patients with prolonged duration. According to WebMD (2017) diabetes coupled with nonadherence increases the risk for neuropathy, and foot ulcer. Lack of tight glycemic control triggers

an axonal neuropathic process that damage vulnerable nerves particularly the long nerves Diabetic neuropathy diminishes protective sensation and muscle coordination in the lower extremities due to denervation of the small muscles of the foot. Diabetic neuropathic foot ulcers occur due to some mechanical changes in bony conformation hence altering the architecture of the foot, peripheral neuropathy, and peripheral arterial disease (Papadakis et al. 2015).

Previous Studies Using the Proposed Methodology

Nonadherence to medical treatment is a problem that has gained enormous attention. Researchers worldwide have done extensive studies to identify the cause of the problem and to find solution to nonadherence. Quilliam, Ozbay, Sill and Kogut (2013) used secondary data obtained from Medstat MarketScan database to measure the association between adherence to oral antidiabetic drugs and hypoglycemia in persons with Type 2 diabetes. Medstat MarketScan collected their data through a cross sectional correlational study design. The investigators included inpatient and outpatient medical visits records, pharmacy claims records, and patient eligibility files from 2004 to 2008. The MarketScan database captured all relevant healthcare information, both inpatient and outpatient, including medical visits and pharmacy claims.

Quilliam et al. (2013) conducted a retrospective study using a new user design record to quantify the association between patient adherence to metformin, sulphonylurea or thiazolidinedione, and the incidence of hypoglycemic events during the same period. The researchers identified Type 2 diabetics as their target population, and specifically those managed on metformin, sulphonylurea or thiazolidinedione. They established the

following inclusion criteria: the patient must be at least 18 years of age, have had two claims with a Type 2 diabetes diagnosis confirmed by The International Classification of Diseases (ICD-9) code 250.X, 250.X0 or 250.X2, or have had at least one pharmacy claim for metformin, a sulphonylurea or a thiazolidinedione. The difference between the study conducted by Quilliam et al. (2013) and my proposal is that I will be exploring correlations between patient adherence to antidiabetic medication and diabetic complications, while Quilliam et al. (2013) examined the association of antidiabetic medications with a major side effect, which is hypoglycemia.

Summary and Conclusion

Studies have shown that tight glucose control reduces diabetic complications among people with diabetes (Shivashankar et al., 2016; Medscape, 2017). The American Diabetes Association (ADA) clinical practice guideline presents sufficient evidence that supports the need for tight glycemic control (ADA, 2016). Diabetes mellitus is a chronic metabolic disorder that has become global epidemics with enormous social, health, and economic implications (Shivashankar et al., 2016). The National Diabetes Statistics report revealed that in 2014, 29.1 million individuals or 9.3% of the American population were living with diabetes mellitus. The same report suggested that only 21 million of those living with diabetes were diagnosed, while about 8.1 million people were undiagnosed (CDC, 2016). WHO (2016) statistical evidence suggested that in 2014 an estimated 422 million people worldwide were living with diabetes mellitus. It is anticipated that in the next couple of years, the prevalence rate of diabetes mellitus will increase to about 530 million if adequate preventive measures and better control or cure

is not in place. Empirical data had shown that about 50% of the putative diabetics are not diagnosed until 10 years after onset of the disease or when some diabetic complications such as retinopathy, diabetic nephropathy or cardiovascular diseases have started manifesting.

In this quantitative study, I explored whether there were any predictive relationships between patient adherence to medication for diabetes and severity of diabetic complications among diabetics in Jamaica. I will use the cross-sectional design for this study. For this quantitative, correlational study I used data obtained from both in and out patients who had been diagnosed with either Type 1 or Type 2 diabetes mellitus in public hospital and private clinics in Jamaica. In chapter 3 I will describe the research method, purpose of study, research design and rationale, target population, sampling and sample procedure, procedure used for collection of archived data, procedure I used to access archived data, instrumentation and operationalization of constructs, ethical procedures and threats to internal, external and statistical validity.

Chapter 3: Research Method

Introduction

The purpose of this study was to explore the predictive relationships between patient nonadherence to antidiabetic medication and HbA1C with diabetic retinopathy, diabetic nephropathy, cardiovascular diseases, and diabetic neuropathic foot ulcers. In this chapter, I will describe the research design and rationale. I will define both the independent and dependent variables, identify my research design and its relevance to the study and explain time and resource constrains. I will also define my target population, sampling, sample size, procedure used for collecting archival data, and data analysis using the SPSS.

Research Designs and Rationale

In this quantitative study, I explored whether there were predictive relationships between adherence to medication for diabetes and HbA1C with diabetic complications among people with diabetes in Jamaica. I employed a correlational approach to investigate the extent to which levels of adherence to antidiabetic medication corresponds with diabetic complication. The correlational study approach is one of the most commonly used research designs in health promotion. Creswell (2013) suggested that it was also the most appropriate design for this study because no control was required in this kind of study. In addition, I used the correlational design because Kellar and Kelvin (2013) argued it was useful for predicting the strength and direction of the relationship between variables. The correlational study design was appropriate for this study because it enabled me to address the link between nonadherence to antidiabetic medication and

diabetic complications such as diabetic retinopathy, diabetic nephropathy, cardiovascular disease, and diabetic neuropathic foot ulcer.

Variables

The independent variables in this study were adherence to recommended treatment, which was adherence to antidiabetic medication and HbA1C. Adherence to physicians' prescribed medication refers to the extent to which a patient takes a given medication as recommended by a healthcare provider (Ho, Bryson, & Rumsfeld, 2009). Adherence was determined by interviewer administered Morisky 8-item Adherence Scale questionnaire. The Morisky 8-item Adherence Scale measures levels of adherence from 0–8 and a patient could score 0 or 1 on each question. A patient was considered adherent when he/she had cumulative score of 7 – 8 points or nonadherent when the patient had cumulative score of 0 – 6. Another independent variable used in this study was the glycated hemoglobin (HbA1C) which Kaplan step2 (2018) refers as a form hemoglobin that is measured to determine glycemic control within the last previous months. The dependent variables were diabetic complications such as cardiovascular disease, retinopathy, nephropathy, and diabetic neuropathic foot ulcers.

Methodology

Population Description

According to Population World (2018), the population of Jamaica in 2017 was estimated to be 2,990,561, with a predominantly Black population at about 92.1%, mixed race 6.1%, East Indian 0.8%, other races 1.1%. Approximately 43% of Jamaicans were single, 38% were married or in a form of union. About 50% of the population had at least

a high school education. Jamaicans who reported they had tertiary level education were about 11.3%. About 60% of Jamaicans ages 15-74 years were employed, 45% had full time paid employment. The JHLS revealed that 40% of Jamaicans were unemployed during the 2008 survey which was the most current survey of that nature done in Jamaica.

According to Wilks et al. (2008) 33% of Jamaicans have a parent or grandparent with diabetes and about half (1/2) of the 33% of population adopted lifestyle changes. Private health insurance is not common in Jamaica, only 19% of Jamaicans had private health insurance and men were more likely to have the benefit than women. Most Jamaicans depend on the free healthcare provided by the government in addition to a National Health Fund (NHF) a complementary pharmacy card solely for purchase of medications (Wilks et al. 2008).

Data Collection

Data were collected from a dataset I obtained from a General Hospital in Jamaica. The hospital is in a parish that has a population of 246,322 people and accepts patients from all parts of the island. The hospital collected the data by a cross-sectional review of patients' dockets, an interviewer-administered Morisky 8-item Adherence Scale, and ICD-9 for chronic disease classifications. Good data quality was ensured by comparing responses to questionnaires with medical records. The independent variable-adherence to antidiabetic medications, was coded as levels of adherence (0–8), while the second independent variable- HbA1c levels, were coded from 1 upwards. Diabetic complications such as cardiovascular disease, diabetic neuropathic foot ulcer, diabetic retinopathy, and diabetic nephropathy were coded as: 0 = no complication, 1 = moderate complication, 2 =

severe complication. Pallant (2010) suggested that the dataset must be checked for error within each variable for scores that were not within an acceptable range; identified error must be corrected or deleted before proceeding for analysis.

Sampling and Sampling Procedure

The records came from individuals who presented at outpatient or inpatient at the General Hospital. I used the G*Power analysis to calculate the minimum sample size required to detect an effect. The G*Power analysis was used to calculate the optimum sample size. The results showed that a total of 111 samples would be needed to have an actual power of 0.9503016, Df of 109, critical t of 1.6589535, and noncentrality parameter delta of 3.3133098. The effect size | p | is 0.3, alpha error probability is 0.05 and power (1-beta err probability) of 0.95. I purposefully selected records from the database and the inclusion criteria to include in the data analysis.

Recruitment, Participation and Data Collection

The medical records that I used for this study were for individuals who attended the public General Hospital as inpatients and outpatients and were diagnosed of diabetes mellitus Type 1 or Type 2. These individuals were between the ages 18 years to 95 years when they visited the General Hospital between January 2015 to January 2017. The data collection was part of the hospital efforts to improve both the intensity and quality of care for the patients. The hospital keeps medical records in dockets which is used to review patients whenever they return to the hospital. The Morisky 8-item Adherence Scale was administered to people with diabetes who visited the hospital for treatment and chose to participate. The questionnaires were read out to patients who could not read or who

needed assistance for clarity and understanding of the questions. The hospital also offered HbA1c test to the patients as part of the data collection and to determine glycemic control within the previous 3 months.

Validity and reliability of data collection and record keeping

In a quantitative study, the researcher must be concerned with the accuracy and validity of the data collection techniques. Content validity refers to the degree to which an adopted measurement technique includes all the essential questions needed to determine the variable of interest, which in this study was the dependent variable of medication adherence (Grove & Cipher, 2017). The hospital data collection process addressed the concerns regarding the validity and reliability of data collected on patient adherence to medication by developing a standard operating procedure (SOP) that ensured that only an already validated and standardized instrument would be used in the data collection related to the independent variable, which was adherence to medication. The hospital used the Morisky 8-item Medication Adherence Scale (MMAS-8) questionnaire without any form of modification and it was followed up with HbA1c test to determine glycemic control. Junior doctors were trained to administer the MMAS-8 questionnaires and to score them according to standard procedure. The staff at the medical records department were trained to enter the results in the database. Entered data are reviewed periodically to ensure that data are accurately entered a junior doctor. The General Hospital used this data to improve quality of care for their patients. As a result, I assumed that the process and instrument used to collect the data was valid and reliable.

Data on the dependent variables were collected through reliable and valid hospital machinery. The HbA1c results were computer generated from blood samples sent to the hospital laboratory. The instruments the hospital used were adequately calibrated and duplicate measures were done to ensure good data quality. The computer-generated results were reviewed by a trained medical technologist before the data were entered into medical records by the junior doctors. The medical records were periodically reviewed by a junior doctor to ensure accuracy of test results. Data on the operational dependent variables of retinopathies, nephropathies, cardiovascular diseases, and neuropathic diabetic foot ulcers were generated through ICD-9 codes. The ICD-9 codes were determined by trained junior doctors who extracted the information from the patients' medical dockets in the hospital and recorded diabetic complications according to severity. The data were subsequently entered into the database by trained staff in the medical records. Data were reviewed periodically for accuracy by a trained junior doctor.

Procedure for Gaining Access to Data Set

I obtained permission from the senior medical officer (SMO) of the hospital, to access archived data that was gained for the secondary analysis in this dissertation. I received a letter of approval dated October 25, 2017 from the hospital and a copy of approval is included in Appendix A. I sorted the data and those essential to study were selected. I removed all forms of personal identifiers to ensure that the identity of the patients was not compromised. A data set was created from the data obtained, and all the variables were entered and defined in SPSS. No historical or legal documents were used

as sources of data; only the archived medical records of individuals from the hospital were used to gather data related to the variables of interest for this study.

Data Analysis Plan

The focus of my data analysis was to explore associations between independent variables (patient adherence and HbA1c levels) and dependent variables (diabetic complications). The plan for data analysis involved establishing and testing the null and alternative hypothesis and determining the alpha level which is the statistical significance level. Assumptions of correlational study designs include: (a) the dependent variables must be continuous, interval, or ratio and the independent variables must be continuous or dichotomous; (b) the relationship between dependent variable and independent variables should be approximately linear; (c) the variables must have a relatively normal distribution; (d) there must not be major outliers among the data; (e) for each value of independent variables the variance of error terms observed must be constant; and (f) the independent variables should not be highly correlated (Kellar & Kelvin, 2013). I ascertained that the data met all assumptions of correlational study design. I also determined that the variations in the dependent variables is explained by the independent variables. Kellar and Kelvin (2013) suggested that another integral part of data analysis plan was to determine the relationship between each independent variable and dependent variable, and subsequently determine the relative strength of the association of each independent variable on the dependent variables.

I used the SPSS to run multiple regression analyses to test the null hypotheses for the research questions. Multiple regression involves the analysis of two or more

independent variables. I used this procedure to determine whether the independent variables predicted the outcome variables, which was the dependent variables. I used the SPSS to perform collinearity diagnostics, homoscedasticity, linearity and normality of all the variables. I checked these assumptions by inspecting the normal probability plot (p-p) of the standardized residual and scatterplot. According to Pallant (2010) the normal P-P plot was used to determine if there were major deviations in normality while the scatterplot was used to check for linearity of the model and independent error assumption.

I used the SPSS to run multiple regression analysis that is fundamentally used for analyzing multiple dependent and independent variables. Kellar and Kelvin (2013) suggested that the beta coefficients provided information regarding predicted changes in the outcome with respect to changes in each independent variable when all other factors are kept constant.

Morisky Medication Adherence Scale

The public hospital used the Morisky 8-item Adherence Scale to collect data on the independent variable of adherence to medical treatment. A self-reported tool that was developed by Morisky et al. in 1986, the instrument was termed the Morisky Medication Adherence Scale (Mercy Clinic, 2018). The Morisky 8-item Adherence Scale has been validated many times and found to have high internal reliability, high specificity, and high sensitivity (Okello, Nasasira, Muiru, & Muyingo, 2016). According to Morisky, Ang, Krausel-Wood, and Ward (2008) the original instrument, which was used to assess adherence to medication for patients with hypertension, had good internal

consistency reliability as evidenced by a Cronbach's alpha equal to .83. The sensitivity or accuracy for identifying patients with hypertension of was 93% while the specificity or accuracy for identifying individuals without hypertension was 55%. The construct validity of the original instrument was supported by results from a confirmatory factor analysis, which presented a root mean square error of approximation <0.0101.

The psychometric properties of the MMAS- 8 have also been investigated in several international studies. Cuevas and Penate (2014) validated the psychometric properties of MMAS-8 with a Spanish sample. Results from their study revealed that the internal consistency reliability, as measured by Cronbach's alpha was equal to .75. The confirmatory factor analysis confirmed on the factor solution showed a GFI of .99, which was evidence of construct validity. Okello, Nasasira, Muiru, and Muyingo (2016) also tested the psychometric properties of the MMAS-8 with Ugandan a sample and found that the internal consistency reliability or Cronbach's alpha was equal to .65. However, their test-retest reliability was low with a weighted kappa equal to 0.36 (95% CI-0.01,0.73). The overall Kaiser's measure of sampling adequacy for residuals of 0.72 supported the construct validity through the factor.

Scores on the MMAS-8 are assigned based on the patient's response to eight scale questions that is yes or no (Al-Qazaz, Hassali, Shafie, Sulaiman, Sundram, & Morisky, 2010). Questions 1 to 7 on the Morisky-8 Item Adherence Scale focused on establishing whether a patient takes his/her medications as prescribed, and situations that may encourage nonadherence to prescribed medications. Responses to questions 1 to 4, and 6

were measured as yes, equal to zero (0) point, or no, equal to one (1) point each. Question 5 response is coded as yes, equal to one (1) point, and no, is equal to zero (0).

Question 8 was about how often the individuals had difficulty remembering to take all their medications as prescribed. Responses to question 8 of the Morisky-8 item medication adherence scale include: (a) never or rarely, which equals four (4) points, (b) occasionally, which equals three (3) points, (c) sometimes, which equals two (2) points, (d) usually, which equals one (1) point, or (e) all the time, which was equal to zero (0) point. Total score points from question 8 was divided by 4 to obtain 1 point or a fraction of a point. The maximum an individual could score in the Morisky 8-item Adherence Scale was 8 points (Plakas et al. 2016). I used this exact scale and psychometrics for this study, no changes were made to the data and I analyzed data as collected by the hospital.

Instrumentation and Operationalization of Variables

The independent variables in this study were patient adherence to antidiabetic medication and HbA1c levels. Adherence to antidiabetic medication was operationally defined as consistently taking antidiabetic medications as prescribed by the attending physician. The Morisky-8 item questionnaire was administered to the individuals, they were required to respond to 8 questions. Each question in the questionnaire was worth 1 point. The questions were used to determine whether the individuals took their antidiabetic medication as recommended by their physicians.

Nonadherence or adherence was determined by calculating the number of points scored by the individual on the Morisky 8-item Adherence Scale. The scores could range from 0 – 8. For this study if an individual had a high of level adherence score (7 or 8),

that individual is considered adherent and if an individual had a low level of adherence (6 or less), that individual was considered non-adherent.

The HbA1c level was measured by immunoassay using the venous blood of the individuals. Levels of HbA1c were used to quantitatively determine an individual's glycemic control within the previous 3 months (Papadakis et al., 2015). HbA1c measurements of 6.5 and below are considered normal and indicative of tight glycemic control. However, measurements above 6.5 are considered abnormal and indicate poor glycemic control (Papadakis et al., 2015).

The operational dependent variables were chronic complications that diabetic patients developed over a period. The operational dependent variables include retinopathies, nephropathies, cardiovascular diseases, and neuropathic diabetic foot ulcers (Abass, Fausto & Kumar, 2010). The severity of diabetic complications was measured using the international classification of chronic disease (ICD- 9). The ICD-9 classifies chronic conditions from 0 to 2, where 0 = no chronic complication reported, 1 = mild to moderate chronic complications and 2 = severe chronic complications.

Research Questions and Hypotheses

Research Question 1 (RQ1). How well do patient adherence to antidiabetic medication and HbA1c levels predict the severity of cardiovascular disease among people with diabetes in Jamaica after controlling for age and gender?

Null Hypothesis ($H_0$1). Patient adherence to antidiabetic medication (Morisky 8-item Adherence Scale) and HbA1c levels are not statistically significant predictors of the

severity of cardiovascular disease among people with diabetes in Jamaica after controlling for age and gender.

Alternative Hypothesis (Ha1). Patient adherence to antidiabetic medication (Morisky 8-item Adherence Scale) and HbA1c levels are statistically significant predictors of the severity of cardiovascular disease among people with diabetes in Jamaica after controlling for age and gender.

Research Question 2 (RQ2). How well do patient adherence to antidiabetic medication and HbA1c levels (glycemic control) predict the severity of retinopathy among people with diabetes in Jamaica after controlling for age and gender?

Null Hypothesis ($H_0$2). Patient adherence to antidiabetic medication (Morisky 8-item Adherence Scale) and HbA1c levels (glycemic control) are not statistically significant predictors of the severity of retinopathy among people with diabetes patients in Jamaica after controlling for age and gender.

Alternative Hypothesis (H_a2). Patient adherence to antidiabetic medication (Morisky 8-item Adherence Scale) and HbA1c levels are statistically significant predictors of the severity of retinopathy among people with diabetes in Jamaica after controlling for age and gender.

Research Question 3 (RQ3). How well do patient adherence to antidiabetic medication and HbA1c levels (glycemic control) predict the severity of nephropathy among people with diabetes in Jamaica after controlling for age and gender?

Null Hypothesis ($H_0$3). Patient adherence to antidiabetic medication (Morisky 8-item Adherence Scale) and HbA1c levels are not statistically significant predictors of the

severity of nephropathy among people with diabetes in Jamaica after controlling for age and gender.

Alternative Hypothesis (Ha3). Patient adherence to antidiabetic medication (Morisky 8-item Adherence Scale) and HbA1c levels are statistically significant predictors of the severity of nephropathy among people with diabetes in Jamaica after controlling for age and gender.

Research Question 4 (RQ4). How well do patient adherence to antidiabetic medication and HbA1c levels predict the severity of neuropathic foot ulcer among diabetic patients in Jamaica after controlling for age and gender?

Null Hypothesis ($H_0$4). Patient adherence to antidiabetic medication (Morisky 8-item Adherence Scale) and HbA1c levels are not statistically significant predictors of the severity of neuropathic foot ulcer among people with diabetes in Jamaica after controlling for age and gender.

Alternative Hypothesis (Ha4). Patient adherence to antidiabetic medication (Morisky 8-item Adherence Scale) and HbA1c levels are statistically significant predictors of the severity of neuropathic foot ulcer among people with diabetes in Jamaica after controlling for age and gender.

Threats to Validity

Threats to Internal Validity

Assessing the internal and external validity helped to ensure that variations observed in the dependent variable undoubtedly originate from variations in the independent variables and not due to confounding factors (Polit & Beck, 2012). To a

great extent, internal and external validity are dependent on how much control has been attained in the study while collecting data. The potential threats to internal validity in this study included inapt collection of patient history, advancing age, clerical error and recall bias (JHLS, 2008). The archived data analyzed were collected through interview administered questionnaires and depended on an individuals' ability to recall events, hence recall bias, patient history and clerical error may affect the internal validity of the study. These factors that may be threats to internal validity were addressed by comparing the information provided in response to the questionnaire with the individual medical records. Observed discrepancies between patients' medical records and responses to questionnaire were either corrected, deleted or rejected.

Threats to external validity

Diabetics with comorbid conditions take numerous medications that could interact with each other. However, it was difficult to test for effects of drug interactions and its interference in treatment and hyperglycemic control (Blackburn, Swidrovich & Lemstra, 2013). The inability to measure and control for variables such as levels of physical activity, healthy diet options, effects of smoking on diabetic complications, socioeconomic factors, environment and undiagnosed co-morbidities pose threats to

Validity of the results from this study. All these factors could potentiate the development and severity of all diabetic complications (Universal Teacher, 2016). It is also essential to mention that a patient's ability to recall taking medication as prescribed by the attending physician and not being honest could be a threat to the validity of result obtained in the study.

Ethical Procedures

Agreement to Gain Access to Data

Permission to access archived data was received, following request sent to the director of non-communicable diseases at the Ministry of Health, Kingston, Jamaica via email, and to the Senior Medical Officer (SMO) in the general hospital, Jamaica. Raw data contained all patient identifiers, which were cleaned and information relevant to the study extracted. Data was coded to eliminate patient identifiers, and risk of exposure, and was subsequently analyzed following receipt of approval from both Walden University and the general hospital.

Treatment of Archival Data

The archived data were safeguarded and will not be divulged to others. Care was taken to prevent unwanted access to archived data, as researcher is ethically obligated to ensure that the use of the data and or the dissemination of study outcome will not do any harm to the system that provided the data, or to the people that accessed the health care system. Therefore, archived data were used solely for this study, and if needed for future studies, researcher is obligated to notify the hospital system. The data obtained will not be shared with any other person or organization. Individual patient informed consents were not needed for this study since it was only secondary data analysis. No treatment or invasive test done was done during for this study. At the end of this study, archived data used for the study will be appropriately destroyed.

Summary

Chapter 3 outlined description of the study design, sample character and sample methods, instrumentation, data analysis and ethical procedures. Rationale was presented for using correlational study design instead of other study designs. The data collection process used by the hospital system in Jamaica was also described. Adequate demographics particularly age and gender which were important for this study were obtained from individuals. A cross-sectional patient medical record review was done along with interviewer administered Morisky 8-item Adherence Scale used to measure an individual's level of medication adherence and HbA1c measured by ELISA method used to determine glycemic control over a 3 months period. The level of adherence and glycemic control/HbA1c are the independent variables while diabetic retinopathy, diabetic nephropathy, cardiovascular disease, and diabetic neuropathic foot ulcer are the dependent variables. A correlational study approach was used to investigate the extent to which levels of adherence to antidiabetic medication corresponds with diabetic complications. Internal and external validity ensured that variations that were observed among dependent variables originated from variations within the independent variables and not because of confounding factors (Polit & Beck, 2012).

Chapter 4: Results

Introduction

The purpose of this study was to explore the predictive relationships between patient adherence to antidiabetic medications, patient HbA1c levels, and diabetic complications among Jamaicans. The general question that guided this research was: How well do the independent variables (patient adherence to antidiabetic medication and HbA1c levels) predict the severity of diabetic complications (retinopathy, nephropathy, cardiovascular disease, and neuropathic foot ulcer) among people with diabetes patients in Jamaica after controlling for age and gender?

Research Question 1 (RQ1). How well do patient adherence to antidiabetic medication and HbA1c levels predict the severity of cardiovascular disease among people with diabetes in Jamaica after controlling for age and gender?

Null Hypothesis ($H_0$1). Patient adherence to antidiabetic medication (Morisky 8-item Adherence Scale) and HbA1c levels are not statistically significant predictors of the severity of cardiovascular disease among people with diabetes in Jamaica after controlling for age and gender.

Alternative Hypothesis (Ha1). Patient adherence to antidiabetic medication (Morisky 8-item Adherence Scale) and HbA1c levels are statistically significant predictors of the severity of cardiovascular disease among people with diabetes in Jamaica after controlling for age and gender.

Research Question 2 (RQ2). How well do patient adherence to antidiabetic medication and HbA1c levels (glycemic control) predict the severity of retinopathy among people with diabetes in Jamaica after controlling for age and gender?

Null Hypothesis ($H_0$2). Patient adherence to antidiabetic medication (Morisky 8-item Adherence Scale) and HbA1c levels (glycemic control) are not statistically significant predictors of the severity of retinopathy among people with diabetes patients in Jamaica after controlling for age and gender.

Alternative Hypothesis (H_a2). Patient adherence to antidiabetic medication (Morisky 8-item Adherence Scale) and HbA1c levels are statistically significant predictors of the severity of retinopathy among people with diabetes in Jamaica after controlling for age and gender.

Research Question 3 (RQ3). How well do patient adherence to antidiabetic medication and HbA1c levels (glycemic control) predict the severity of nephropathy among people with diabetes in Jamaica after controlling for age and gender?

Null Hypothesis ($H_0$3). Patient adherence to antidiabetic medication (Morisky 8-item Adherence Scale) and HbA1c levels are not statistically significant predictors of the severity of nephropathy among people with diabetes in Jamaica after controlling for age and gender.

Alternative Hypothesis (Ha3). Patient adherence to antidiabetic medication (Morisky 8-item Adherence Scale) and HbA1c levels are statistically significant predictors of the severity of nephropathy among people with diabetes in Jamaica after controlling for age and gender.

Research Question 4 (RQ4). How well do patient adherence to antidiabetic medication and HbA1c levels predict the severity of neuropathic foot ulcer among diabetic patients in Jamaica after controlling for age and gender?

Null Hypothesis ($H_0$4). Patient adherence to antidiabetic medication (Morisky 8-item Adherence Scale) and HbA1c levels are not statistically significant predictors of the severity of neuropathic foot ulcer among people with diabetes in Jamaica after controlling for age and gender.

Alternative Hypothesis (Ha4). Patient adherence to antidiabetic medication (Morisky 8-item Adherence Scale) and HbA1c levels are statistically significant predictors of the severity of neuropathic foot ulcer among people with diabetes in Jamaica after controlling for age and gender.

In this chapter I have included information regarding the time frame the hospital used for data collection and their recruitment process as well as the response rates. I present any discrepancies in data collection or deviations from data collection plan presented in the previous chapter. I also present the descriptive and demographic characteristics of the sample. It was essential for me to describe if the sample was a true representation of the target population or the Jamaican population at large. The data were analyzed using multiple regression analysis on SPSS platform.

Data collection

The data I used in this study was obtained from a public hospital that has an ongoing data collection process for information related to chronic diseases and infectious diseases. The archived data used in this study was collected through the Morisky 8-item

Adherence Scale questionnaires were issued to patients between January 2015 to December 2016 to a total of 119 individuals. These were individuals who visited the public hospital within that period and met the participation criteria. The Morisky 8-item Adherence Scale and ICD-9 chronic disease classification questionnaire as well as testing for HbA1c levels by ELISA method were all administered by trained staff. The interviewers were adequately trained and certified by the hospital before they were assigned to the patients. Instruments used were adequately calibrated and duplicate measures were done according to the standard operating procedure (SOP).

Results

Preparing Data for Analysis

Data cleaning is a major part of data preparation that is done before analysis; two types of data cleaning were done before data analysis: the possible code cleaning and contingency cleaning. Kellar and Kelvin (2013) argued that possible code cleaning involved finding and eliminating errors in the data matrix hence ensuring that only answer choices for each question was entered in the associated field. Crossman (2017) suggested that during the contingency cleaning I ensured that only those cases that should have data on a variable do indeed had such data hence, if a number outside the predefined possibilities were entered an error message appeared. I removed all personal identifiers from the data set analysis.

Descriptive statistics

The independent variables were the level of adherence to antidiabetic medications and HbA1c values, the dependent variables included cardiovascular disease, diabetic

retinopathy, diabetic nephropathy, and diabetic neuropathic foot ulcer. Table 1 shows summary of the descriptive variables for each of the variables included in the data analysis. A total of 119 individual medical records were used, of which 42% were male, and 58% were female as also shown in Figure 1.

Levels of adherence to antidiabetic medication was measured with Morisky 8-item Adherence Scale. The mean adherence level was 6.11 with a standard deviation of .35 as shown in Table 1. The chart in Figure 1A reveals that 34.4% of patients had high levels of adherence (adherent), and 65.6% had low level of adherence (non-adherent) to prescribed diabetic treatment. The HbA1c level was used to determine glycemic control within the previous 3 months. The results revealed that the average level of HbA1c was 8.84, which implied that the overall targeted population did not adequately control their glucose levels within the period in question as shown in Table 1. The standard deviation of HbA1c levels was 2.83, indicating that some people with diabetes in this target population had HbA1c as high as 11.67 while others had HbA1c as low as 6.01. As shown in Figure 1B, only 25.2% of the individual had normal HbA1c (4.62 – 6.50) while 74.8% had abnormal levels of HbA1c (6.60 – 18.03).

Figure 2 shows that 59.7% of the diabetic population did not report, and were not diagnosed with cardiovascular disease, while 15.1% had mild cardiovascular disease, and 25.2% had severe cardiovascular disease. Data in Table 1 show that the mean for the severity of cardiovascular disease was 0.66, with a standard deviation of 0.86 which indicated that the frequency of cardiovascular disease among the targeted population was

as high as 1.52 in some individuals, while cardiovascular disease was not reported or diagnosed in some individuals within the population.

Figure 2 also shows that 72.3% of the people with diabetes did not have diabetic retinopathy, 21% had mild retinopathy while 6.7% had severe diabetic retinopathy. The average score for severity of diabetic retinopathy was 0.34 with standard deviation of 0.603 which also implies that the frequency of diabetic retinopathy among individuals was as high as 0.943, while others did not report the disease. Table 1 and figure 3 show that 83.2% of the patients were not diagnosed with diabetic nephropathy, 8.4% had mild nephropathy while another 8.4% had severe diabetic nephropathy. The mean severity of diabetic nephropathy was 0.25 with standard deviation of 0.600 which indicates that the frequency nephropathy was as high as 0.85 among some individuals while others did not have the disease at all. As shown in Table 1 and Figure 2, 77.3% of the patients were not diagnosed with diabetic neuropathic foot ulcer, 9.2% had mild diabetic neuropathic foot ulcer while 13.4% had severe diabetic neuropathic foot ulcer. The mean severity of diabetic neuropathic foot ulcer was 0.36 with a standard deviation of 0.710 which means that the frequency of neuropathic foot ulcer was as high as 0.85 among some people with diabetes while some others did not report the complication.

Table 1

Summary of Descriptive Statistics of Variables

Variables		Frequency	Percent	Mean	Std. Deviation	N
Gender	Male	50	42			
	Female	69	58			119
Adherence	3-6	78	65.6	6.11	1.352	
Level	7-8	41	34.4			119

HbA1c Levels 4.62 - 6.50	25.2	25.2			
(Glycemic cont.) 6.60 – 18.03	74.8	74.8			119
No Cardiovascular Disease	71	59.7	.66	.858	
Mild Cardiovascular Disease	18	15.1			
Severe Cardiovascular Disease	30	25.2			119
No Retinopathy	86	72.3	.34	.603	
Mild Diabetic Retinopathy	25	21.0			
Severe Diabetic retinopathy	8	6.7			119
No Nephropathy	99	83.2	.25	.600	
Mild Diabetic Nephropathy	10	8.4			
Severe Diabetic Nephropathy	10	8.4			119
No Neuropathic Foot Ulcer	92	77.3	.36	.710	
Mild Diabetic Neuropathic Foot Ulcer	11	9.2			
Severe Diabetic Neuro Foot Ulcer	16	13.4			119

Figure 1A. Bar charts of gender and levels of adherence.

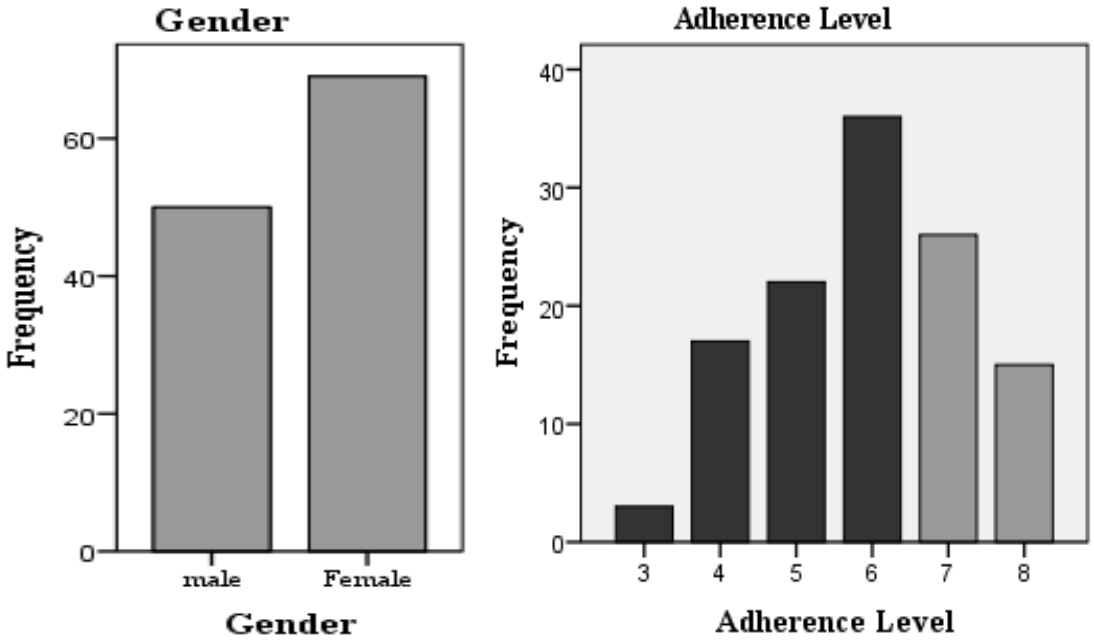


Figure 1B. Bar chart of HbA1c Levels.

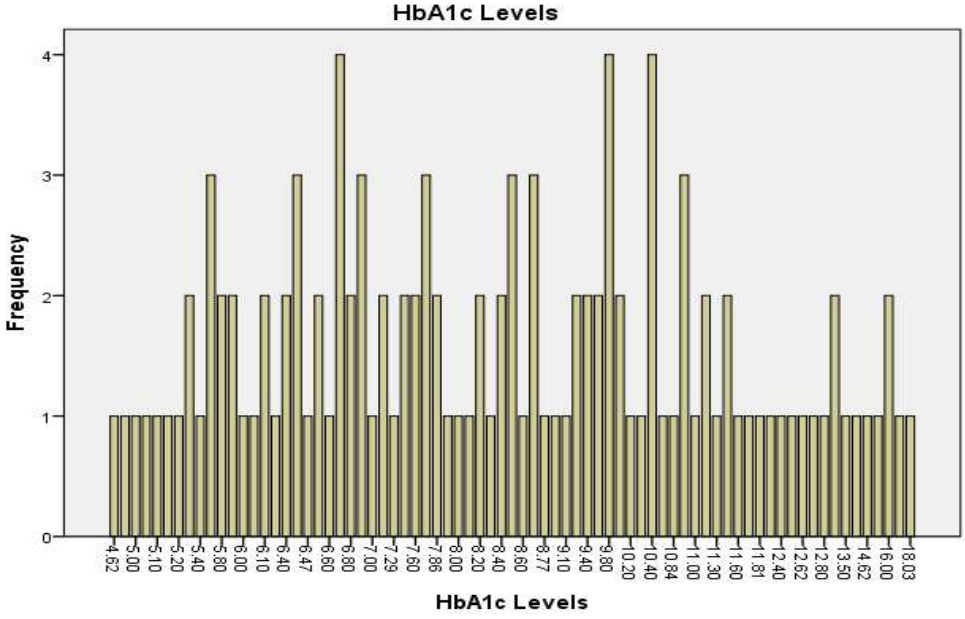


Figure 2. Bar chart of Cardiovascular disease and diabetic retinopathy.

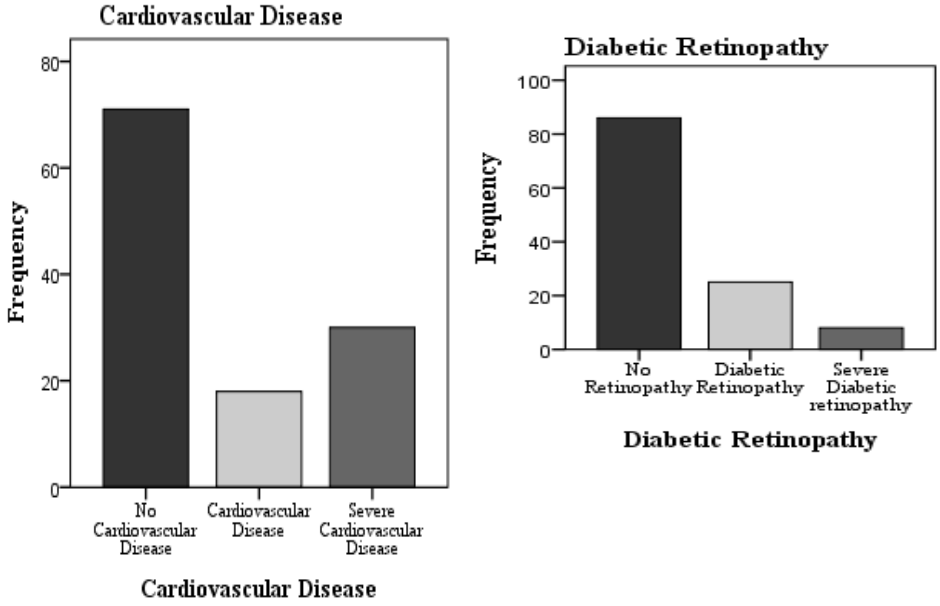
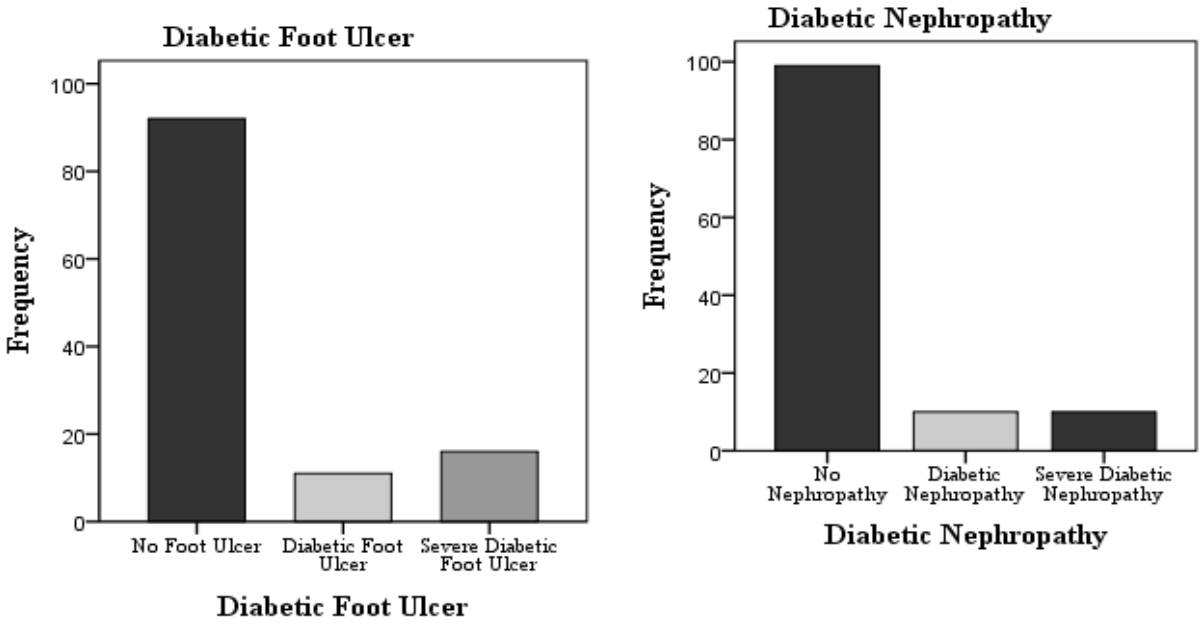


Figure 3. Bar chart of diabetic neuropathic foot ulcer and diabetic nephropathy.



Testing Statistical Assumptions

The statistical assumptions of multiple regression include independence of variables (adherence level and HbA1c levels) must have a linear relationship with the

dependent variables (cardiovascular disease, retinopathy, nephropathy, and neuropathic foot ulcer). The residuals must be normally distributed, the independent variables must not be highly correlated with each other and the variance of error terms must be similar across the values of the independent variables (Kellar & Kelvin, 2013). Figures 4 to 12 below show scatter plots for each of the independent variables versus diabetic complications (dependent variables). The expected cumulative probability of the normal p-p plot is on the y-axis while the observed cumulative probability values are on the x-axis. Normal P-P plot of regression standardized residual suggest that the dependent variables are approximately normally distributed for each independent variable.

I used the scatter plots to check for homoscedasticity, linearity of the model, normality and independent error assumption. The plots show a distribution of data that are relatively evenly distributed around the zero point. The figures also show that there are no major deviations or outliers observed in the randomly displayed data. The scatter plot regression standardized residuals are on the y-axis while the regression standardized predicted values are on the x-axis. The scatter plots show that the residuals and the variance of the residuals are the same for all predicted values. This observation indicates that the assumptions of homoscedasticity, linearity of the model and independent error are met (Kellar & Kelvin, 2013).

Figure 4. Scatterplot of Independent Variables Vs Cardiovascular Disease.

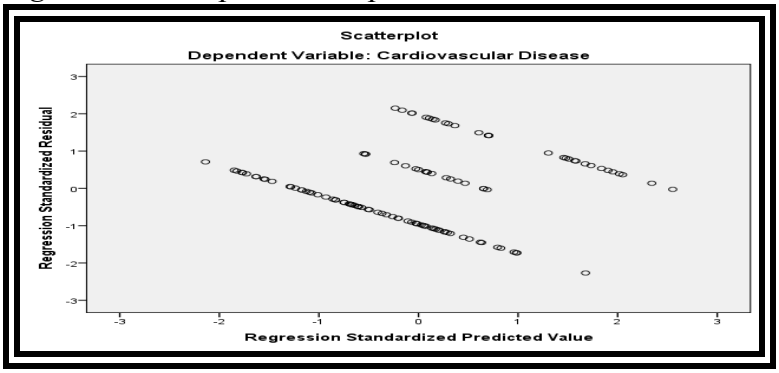


Figure 5. Normal P-P Plot of Independent Variables Vs Cardiovascular Disease.

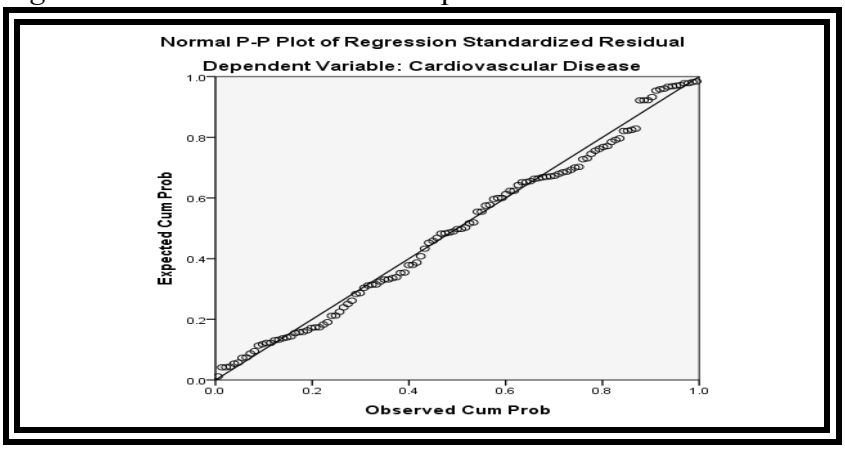


Figure 6. Scatterplot of Independent Variables Vs Diabetic Retinopathy.

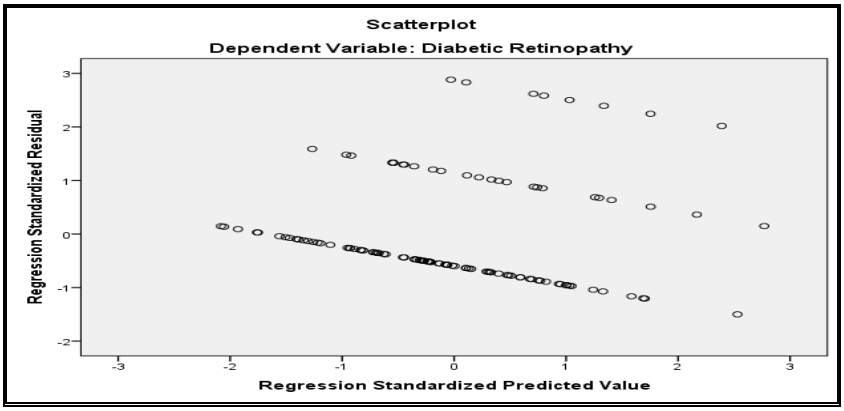


Figure 7. Normal P-P Plot of Independent Variable Vs Diabetic Retinopathy.

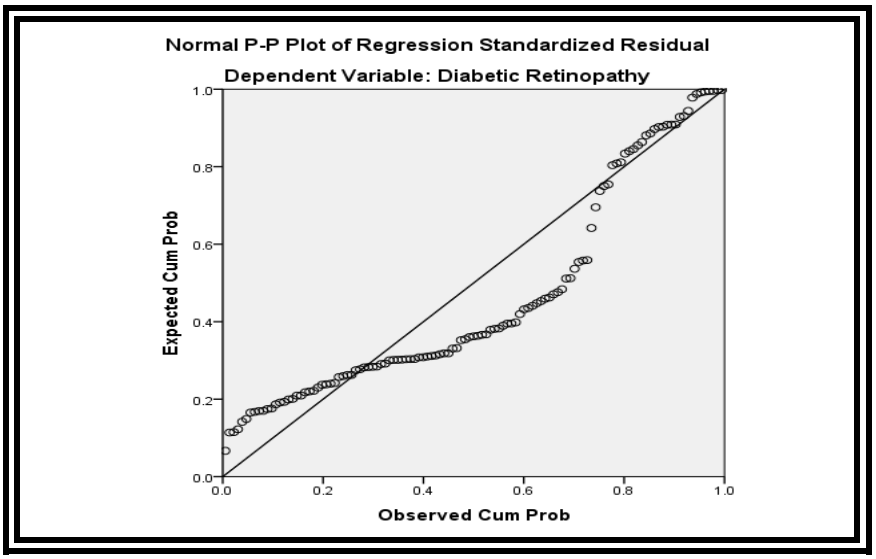


Figure 8. Normal P-P Plot of Independent Variables Vs Diabetic Nephropathy.

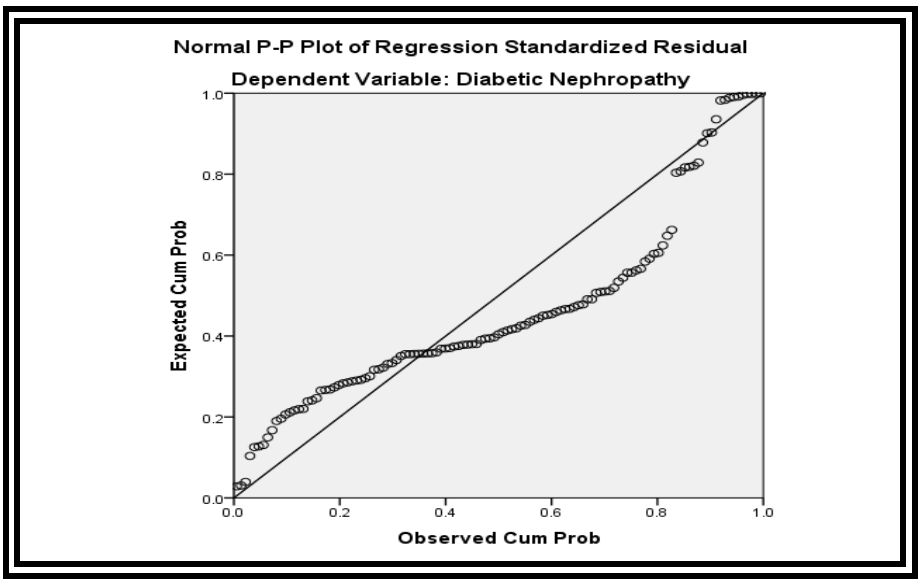


Figure 10. Scatterplot of Independent Variables Vs Diabetic Nephropathy.

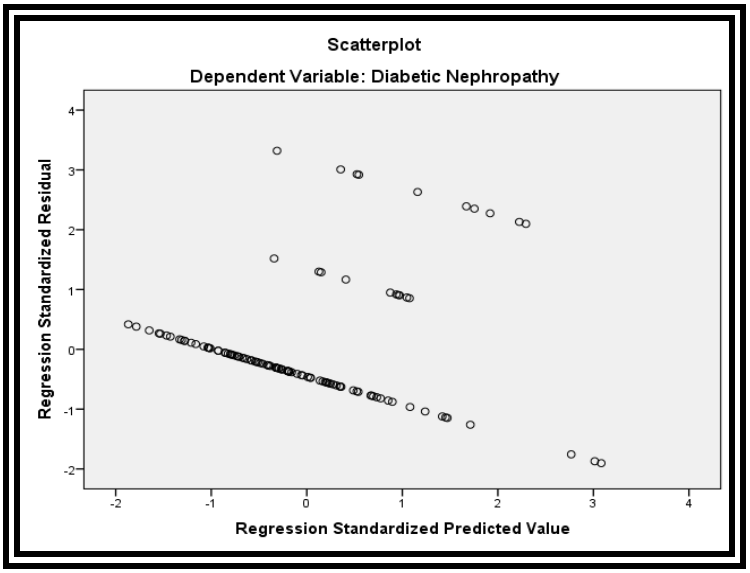


Figure 11. Normal P-P Plot of Independent Variables Vs Diabetic Neuropathic Foot Ulcer.

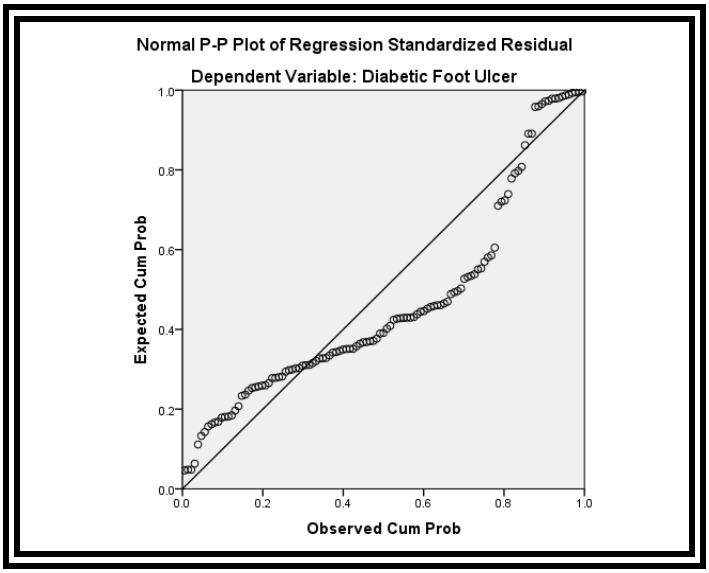
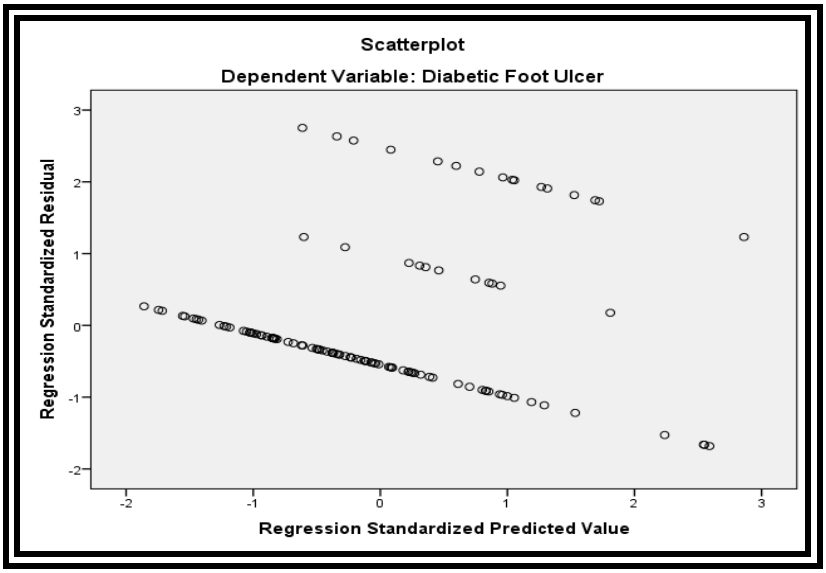


Figure 12. Scatterplot of Independent Variables Vs Diabetic Neuropathic Foot Ulcer.



Inferential statistical analysis

Using statistical inference, I have made propositions regarding my target population, via the data collected from diabetic patients that attended the public hospital during the period. I have proposed my hypothesis about the target population from which I drew inferences. Multiple regression analysis model was used to generate data that inferred statistical properties that included testing hypotheses and descending estimates. My targeted population is assumed to be sampled from a larger population (Konishi & Kitagawa, 2008). Data analyzed included independent variables (adherence to treatment and HbA1c levels) and dependent variables (cardiovascular diseases, diabetic retinopathy, diabetic nephropathy and diabetic neuropathic foot ulcer).

Cardiovascular Disease

RQ1: How well do patient adherence to antidiabetic medication and HbA1c levels predict the severity of cardiovascular disease among people with diabetes in Jamaica after controlling for age and gender?

$H_0$1: Patient adherence to antidiabetic medication (Morisky 8-item Adherence Scale) and HbA1c levels are not statistically significant predictors of the severity of cardiovascular disease among people with diabetes in Jamaica after controlling for age and gender.

H_a1: Patient adherence to antidiabetic medication (Morisky 8-item Adherence Scale) and HbA1c levels are statistically significant predictors of the severity of cardiovascular disease among people with diabetes in Jamaica after controlling for age and gender.

I conducted multiple linear regression analysis to test the null hypothesis for Research Question1. Results from the ANOVA test produced results for two regressions models. The data revealed that variables in both regression models significantly predicted the severity of cardiovascular disease. Model 1 contained age and gender as the covariates that were used to test for the effect of interactions of the independent variables on the dependent variables (severity of cardiovascular disease) variable, F (2,116) = 18.26, p = .000. Model 2 contained patient adherence scores and HbA1c levels as independent variables, age and gender as covariates, and severity of cardiovascular disease as the dependent variables, F (4,114) = 18.00, p = .000.

Table: 2.

ANOVA Summary Table of cardiovascular disease vs independent variables

Model		Sum of Squares	Df	Mean Square	F	Sig.
1	Regression	20.763	2	10.382	18.216	.000[b]
	Residual	66.111	116	.570		
	Total	86.874	118			
2	Regression	33.627	4	8.407	17.999	.000[c]
	Residual	53.247	114	.467		
	Total	86.874	118			

a. Dependent Variable: Cardiovascular Disease

b. b. Predictors: (Constant), Age, Gender

c. c. Predictors: (Constant), Age, Gender, Adherence to treatment, HbA1c levels (Glycemic Control)

The regression model summary is presented in Table 2. Data in this table were used to determine how much each variable contributed to the variance in severity of cardiovascular disease. Data in Table 3 showed that in Model 1, age accounted for 20.763% [R^2=.24, R^2_{adj}=.226, F (2,116) = 18.216, p = .000] of the variance in the severity of cardiovascular disease. Adding patient adherence scores and HbA1C levels in Model 2 resulted in a statistically significant change in the model, R=.622, R^2_{adj}=.387, F (2,114) = 13.771, p = .000] value. Results showed that the R^2_{adj} value by increase by .148, which

indicated a 14.8% change in the amount of variance accounted for by the regression model. Data in table 3 showed that adding patient adherence scores and HbA1C levels increased the amount of variance accounted for in the severity of cardiovascular disease to 36.6% and 22.6% respectively. Both independent variables made statistically significant contributions to the change in variance in cardiovascular disease.

Table 3.

Regression Model Summary of cardiovascular disease

Model	R	R Square	Adj. R Square	Std. Error of the Estimate	Change Statistics				
					R Square Change	F Change	df1	df12	Sig. F Change
1	.489[a]	.239	.226	.755	.239	18.216	2	116	.000
2	.622[b]	.387	.366	.683	.148	13.771	2	114	.000

Beta coefficients were used to determine which variables in the regression model predicted the severity of cardiovascular disease. Results for the unstandardized beta coefficients in Table 4 showed that only age and HbA1c (glycemic control) were statistically significant contributors to the severity of cardiovascular disease. The data showed that each unit of change in age resulted in a change of .026 units in the severity of cardiovascular disease. Results also revealed that each unit of change in HbA1C levels resulted in .114 units of change in the severity of cardiovascular disease. The overall regression equation is presented below:

.203(gender) + .021(age groups) - .022 (patient adherence to treatment) + .114 (glycemic control/HbA1C) = severity of cardiovascular disease

Table 4.

Regression Coefficients of cardiovascular disease

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	-1.138	.348		-3.273	.001
	Gender	.107	.141	.062	.763	.447
	Age	.026	.004	.481	5.921	.000
2						
	(Constant)	-1.837	.698		-2.632	.010
	Gender	.203	.129	.118	1.576	.118
	Age	.021	.004	.383	5.047	.000
	adherence to medication	-.022	.063	-.034	-.339	.735
	Glycemic Control/HbA1c	.114	.031	.376	3.700	.000

Diabetic Retinopathy

RQ2: How well do patient adherence to antidiabetic medication and glycemic control/HbA1c levels predict the severity of diabetic retinopathy among diabetic patients in Jamaica after controlling for age and gender?

$H2_0$: Patient adherence to antidiabetic medication (Morisky 8-item Adherence Scale) and Glycemic control/HbA1c levels are not statistically significant predictors of the severity of diabetic retinopathy among diabetic patients in Jamaica after controlling for age and gender.

$H2_A$: Patient adherence to antidiabetic medication (Morisky 8-item Adherence Scale) and Glycemic control/HbA1c levels are statistically significant predictors of the severity of diabetic retinopathy among diabetic patients in Jamaica after controlling for age and gender.

Multiple linear regression analysis was conducted to test the null hypothesis for Research Question 2. Result from the ANOVA test produced results for two regressions models. The data revealed that variables in both regression models significantly predicted the severity of diabetic retinopathy. As shown in table 5 model 1 contained age and gender (covariates) as independent variables and the severity of diabetic retinopathy as the dependent variable, F (2,116) = 4.937, p = .009. Model 2 contained patient adherence scores and glycemic control/HbA1c levels as independent variables, age and gender as covariates, and severity of diabetic retinopathy as the dependent variables, F (4,114) = 3.761, p = .007.

Table: 5.

ANOVA Summary Table of Diabetic Retinopathy

Model		Sum of Squares	Df	Mean Square	F	Sig.
1	Regression	3.363	2	1.682	4.937	.009[b]
	Residual	39.511	116	.341		
	Total	42.874	118			
2	Regression	4.998	4	1.250	3.761	.007[c]
	Residual	37.875	114	.332		
	Total	42.874	118			

a. Dependent Variable: Diabetic Retinopathy
b. Predictors: (Constant), Age, Gender
c. Predictors: (Constant), Age, Gender, Adherence or Nonadherence, Glycemic Control

The regression model summary is presented in Table 6. Data in this table were used to determine how much each variable contributed to the variance in severity of diabetic retinopathy. Data in Table 9 showed that in Model 1, age and gender accounted

for 6.3% [R^2=.078, R^2_{adj}=.063, $F(2,116)=4.937$, $p = .009$] of the variance in the severity of diabetic retinopathy. When patients' adherence scores and glycemic/HbA1C levels were added in Model 2 they resulted in a statistically significant change in the model, R^2=.341, R^2_{adj}=.086, $F(2,114)=2.461$, $p = .09$] value. Result show that the R^2_{adj} value increased by .038, which indicated a 3.8% change in the amount of variance accounted for by the regression model. Data in table 9 showed that adding patient adherence scores and glycemic control/HbA1C levels increased significantly the amount of variance accounted for in the severity of diabetic retinopathy accounted for by regression model to 8.6%.

Table 6.

Regression Model Summary of Diabetic Retinopathy

Model	R	R Square	Adjusted R Square	Std. of the Estimate	Change Statistics				
					R Square Change	F Change	df1	df2	Sig. F Change
1	.280a	.078	.063	.584	.078	4.937	2	116	.009
2	.341b	.117	.086	.576	.038	2.461	2	114	.090

Beta coefficients were used to determine which variables in the regression model predicted the severity of diabetic retinopathy. Results for the standardized beta coefficients in Table 7 showed that only age group was statistically significant contributors to the severity of diabetic retinopathy as measured. The data show that each unit of change in age resulted in a change of .009 units in the severity of diabetic retinopathy. Both HbA1c and adherence to treatment were statistically insignificant to the severity of retinopathy. The overall regression equation is presented below:

-.047(gender) + .009(age groups) + .009 (patient adherence to treatment) + .046 (glycemic control/HbA1C = severity of diabetic retinopathy

Table 7.

Regression Coefficients of Diabetic Retinopathy

Model		Unstandardized Coefficients		Standardized Coefficients		
		B	Std. Error	Beta	T	Sig.
1	(Constant)	-.178	.269		-.662	.509
	Gender	-.084	.109	-.069	-.776	.439
	Age	.011	.003	.276	3.091	.002
2	(Constant)	-.586	.589	-.996	.322	
	Gender	-.047	.109	-.039	-.432	.667
	Age	.009	.003	.228	2.504	.014
	Adherence	.009	.053	.021	.172	.863
	HbA1c Levels	.046	.026	.216	1.772	.079

Dependent variable retinopathy

Diabetic Nephropathy

RQ3: How well do patient adherence to antidiabetic medication and glycemic control/HbA1c levels predict the severity of nephropathy among people with diabetes in Jamaica after controlling for age and gender?

$H3_0$: Patient adherence to antidiabetic medication (Morisky 8-item Adherence Scale) and Glycemic control/HbA1c levels are not statistically significant predictors of the severity of nephropathy among people with diabetes in Jamaica after controlling for age and gender.

$H3_A$: Patient adherence to antidiabetic medication (Morisky 8-item Adherence Scale) and HbA1c levels are statistically significant predictors of the severity of nephropathy among people with diabetes in Jamaica after controlling for age and gender.

The null hypothesis was tested by conducting multiple linear regression analysis for Research Question 3. Result from the ANOVA test produced results for two regressions models. The data revealed that variables in both regression models significantly predicted the severity of diabetic nephropathy. Model 1 contained age and gender covariates and the severity of disease diabetic nephropathy as the dependent variable, F (3,470) = 5.166, p = .007. Model 2 contained patient adherence scores and glycemic control/HbA1c levels as independent variables, age and gender as covariates, and severity of diabetic nephropathy as the dependent variables, F (7,871) = 6.490 p = .000.

Table: 8.

ANOVA Summary Table of diabetic nephropathy

Model		Sum of Squares	Df	Mean Square	F	Sig.
1	Regression	3.470	2	1.735	5.166	.007[b]
	Residual	38.697	116	.336		
	Total	42.437	118			
2	Regression	7.871	4	1.968	6.490	.000[c]
	Residual	34.566	114	.303		
	Total	42.437	118			

a. Dependent Variable: Diabetic Nephropathy
b. Predictors: (Constant), Age, Gender
c. Predictors: (Constant), Age, Gender, Adherence or Nonadherence, Glycemic Control/HbA1c

The regression model summary is presented in Table 9. Data in this table were used to determine how much each variable contributed to the variance in severity of diabetic nephropathy. Data in Table 6 showed that in Model 1, age and gender accounted for 6.6% [R^2=.082, R^2_{adj}=.066, F(2,116)=5.166, p = .007] of the variance in the severity

of diabetic nephropathy. Adding patient adherence scores and HbA1C levels in Model 2 resulted in a statistically significant change in the model, R^2=.185, R^2_{adj}=.157, $F(2,114)=7.257$, p = .001] value. Results show that the R^2_{adj} value increased by .104, which indicated a 10.4% change in the amount of variance accounted for by the regression model. Data in table 6 showed that adding patient adherence scores and HbA1C levels increased the amount of variance accounted for in the severity of diabetic nephropathy to 15.7%.

Table 9.

Regression Model Summary of Diabetic Nephropathy

Model	R	R Square	Adj. R Square	Std. Error of the Estimate	Change Statistics				
					R Square Change	F Change	df1	df12	Sig. F Change
1	.286[a]	.082	.066	.580	.082	5.166	2	116	.007
2	.431[b]	.185	.157	.551	.104	7.257	2	114	.001

Beta coefficients were used to determine which variables in the regression model predicted the severity of diabetic nephropathy. Results for the standardized beta coefficients in Table 10 showed that only age and glycemic control/HbA1C were statistically significant contributors to the severity of diabetic nephropathy. The data show that each unit of change in age resulted in a change of .008 units in the severity of diabetic nephropathy. Results also revealed that each unit of change in glycemic control/HbA1C levels resulted in .086 units of change in the severity of diabetic nephropathy. The overall regression equation is presented below:

-.04(gender) + .008(age groups) + .055 (patient adherence to treatment) + .086 (glycemic control/HbA1C = severity of diabetic nephropathy

Table 10.

Regression Coefficients of Diabetic Nephropathy

Model		Unstandardized Coefficients		Standardized Coefficients		
		B	Std. Error	Beta	T	Sig.
1	Constant	-.238	.267		-.892	.374
	Gender	-.106	.108	-.088	-.981	.329
	Age	.011	.003	.278	3.121	.002
2	Constant	-1.262	.562		-2.243	.027
	Gender	-.040	.104	-.033	-.382	.703
	Age	.008	.003	.205	2.349	.021
	Adherence level	.055	.051	.123	1.070	.287
	HbA1c / Glycemic control	.086	.025	.404	3.449	.001

Diabetic Neuropathic Foot Ulcer

RQ4: How well do patients adherence to antidiabetic medication and glycemic control/HbA1c levels predict the severity of neuropathic foot ulcer among people with diabetes in Jamaica after controlling for age and gender?

$H4_0$: Patient adherence to antidiabetic medication (Morisky 8-item Adherence Scale) and Glycemic control/HbA1c levels are not statistically significant predictors of the severity of neuropathic foot ulcer among people with diabetes in Jamaica after controlling for age and gender.

$H4_A$: Patient adherence to antidiabetic medication (Morisky 8-item Adherence Scale) and glycemic control/HbA1c levels are statistically significant predictors of the

severity of neuropathic foot ulcer among people with diabetes in Jamaica after controlling for age and gender.

The null hypothesis for Research Question 4 was tested by conducting multiple linear regression analysis. The ANOVA test produced results for two regressions models. The data revealed that variables in both regression models significantly predicted the severity of diabetic neuropathic foot ulcer. Model 1 contained age and gender (covariates) as independent variables and the severity of diabetic neuropathic foot ulcer as the dependent variable, F (2,116) = 3.738, p = .027. Model 2 contained patient adherence scores and glycemic control/HbA1c levels as independent variables, age and gender as covariates, and severity of diabetic neuropathic foot ulcer as the dependent variables, F (4,114) = 5.655, p = .000.

Table: 11.

ANOVA Summary Table of Diabetic Neuropathic Foot Ulcer

Model		Sum of Squares	Df	Mean Square	F	Sig.
1	Regression	3.600	2	1.800	3.738	.027[b]
	Residual	55.862	116	.482		
	Total	59.462	118			
2	Regression	9.845	4	2.461	5.655	.000[c]
	Residual	49.618	114	.435		
	Total	59.462	118			

a. Dependent Variable: Diabetic Foot Ulcer

b. Predictors: (Constant), Age, Gender

c. Predictors: (Constant), Age, Gender, Adherence or Nonadherence, Glycemic Control/HbA1c

The regression model summary is presented in Table 12. Data in this table were used to determine how much each variable contributed to the variance in severity of neuropathic foot ulcer. Data in Table 12 showed that in Model 1, age and gender accounted for 4.4% [R^2=.061, R^2_{adj}=.044, $F(2,116)=3.738$, $p = .027$] of the variance in the severity of diabetic neuropathic foot ulcer. Adding patient adherence scores and glycemic control/HbA1C levels in Model 2 resulted in a statistically significant change in the model, R^2=.105, R^2_{adj}=.136, $F(2,114)=7.174$, $p = .001$] value. Results show that the R^2_{adj} value by increase by .105, which indicated a 10.5% change in the amount of variance accounted for by the regression model. Data in table 12 also showed that adding patient adherence scores and glycemic control/HbA1C levels increased the amount of variance accounted for in the severity of diabetic neuropathic foot ulcer to 13.6%.

Table 12.

Regression Model Summary Diabetic Neuropathic Foot Ulcer

				Change Statistics					
Model	R Square	Adjusted R Square	Std. Error of the Estimate	R Square Change	F Change	df1	df2	Sig. F change
1	.246a	.061	.044	.694	.061	3.738	2	116	.027
2	.407b	.166	.136	.660	.105	7.174	2	114	.001

The beta coefficients were used to determine which variables in the regression model predicted the severity of diabetic neuropathic foot ulcer. Results for the standardized beta coefficients in Table 12 showed that only glycemic control/HbA1c was statistically significant contributor to the severity of diabetic neuropathic foot ulcer after controlling for age and gender. Results in Table 13 revealed that each unit of change in

glycemic control/HbA1C levels resulted in .084 units of change in the severity of diabetic neuropathic foot ulcer. The overall regression equation is presented below:

-.021(gender) + .007(age groups) - .003 (patient adherence to treatment) + .084 (glycemic control/HbA1C = severity of diabetic neuropathic foot ulcer

Table 13.

Regression Coefficients of Neuropathic Foot Ulcer

Model		Unstandardized Coefficients B	Unstandardized Coefficients Std. Error	Standardized Coefficients Beta	T	Sig.
1	(Constant)	-.173	.320		-.540	.590
	Gender	-.091	.129	-.063	-.701	.484
	Age	.011	.004	.242	2.685	.008
2	(Constant)	-.777	. 674		-1.153	.251
	Gender	-.021	.125	-.015	-.170	.865
	Age	.007	.004	.161	1.814	.072
	Adherence	-.003	.061	-.005	-.044	.965
	HbA1c	.084	.030	.333	2.809	.006

Dependent Variable: Diabetic neuropathic Foot Ulcer

Summary of Answers to Research Questions

The independent variables are the HbA1C/glycemic control and adherence levels determined by using Morisky 8-item scale while the dependent variables are cardiovascular disease, diabetic retinopathy, diabetic nephropathy, and diabetic neuropathic foot ulcer. The independent variables HbA1c and adherence levels) correlates with cardiovascular disease. Neither HbA1c nor adherence level correlated diabetic retinopathy, however, HbA1c correlated with both diabetic nephropathy and diabetic foot ulcers after controlling for age and gender.

The result indicates that the null hypothesis which suggests that there is no statistical predictive relationship between the independent variables (adherence level and glycemic control /HbA1c) and the dependent variable (cardiovascular disease, diabetic nephropathy and diabetic neuropathic foot ulcer) should be rejected. The P-P plot of regression standardized residual were normal suggesting there were no major deviations from normality. The scatter plots also show even distribution of data above and below the zero axis without obvious outliers.

In chapter 5, I will present a detailed interpretation of the findings of this study, which will be kept within the limits and scope of the study. I will also discuss the limitations of this study and the implications for social change. The methodological, theoretical, and empirical implications of this study will also be described, and strong recommendations and conclusion provided.

Chapter 5: Discussion, Conclusions, and Recommendations

Introduction

The purpose of this quantitative, correlational study was to explore the relationship between levels of adherence to antidiabetic medications, HbA1c levels, and diabetic complications (cardiovascular disease, diabetic retinopathy, diabetic nephropathy, diabetic neuropathic foot ulcer). This study revealed that levels of adherence to antidiabetic medication negatively correlates with diabetic complications while HbA1c levels positively correlate with diabetic complications. Nonadherence to medications prescribed by a physician is a complex behavioral issue that in most cases triggers multidimensional problems. According to Hugtenburg et al. (2013) there are numerous factors that are associated with nonadherence. These factors include when a patient refuses to fill or refill his/her prescriptions in a timely manner, consequently may not commence treatment at all or may not continue treatment as scheduled by the attending physician. Nonadherence also includes when a patient uses more prescribed medications than directed, less medications than prescribed, or deviates from scheduled time of medication administration (Hugtenburg et al., 2013). Results from several studies have shown that nonadherence to antidiabetic medications compromises a patient's ability and opportunity to achieve tight glycemic control, hence patients may face acute and chronic diabetic complications (Costa et al., 2015; Khan et al., 2012; Kumar et al., 2010).

Ferguson, Tulloch-Reid, and Wilks (2010) affirmed that there are only a few published studies regarding patient adherence to medication and diabetic complications in

Jamaica and the Caribbean region. Hence, I have explored the predictive relationships between patient adherence to antidiabetic medications and diabetic complications among Jamaicans. It is my expectation that this study will have positive impact among the target population and will add to the existing knowledge. Results from empirical studies have shown that adherence to antidiabetic medications helps to achieve tight glycemic control, reduce systemic and glomerular hypertension, decrease inflammatory processes, and prevent metabolic syndrome (Kumar et al., 2010; Papadakis et al., 2015). Common diabetic complications observed among the targeted population included: cardiovascular diseases, diabetic retinopathy, diabetic nephropathy, and diabetic neuropathic foot ulcers.

Busko (2014) suggested that patients who are diagnosed with Type 2 diabetes mellitus at a relatively young age are more susceptible to diabetic complications as they get older. This may be due to the long-term effects of uncontrolled hyperglycemia on the microvasculature and organs. According to findings from several studies, tight glucose control reduces diabetic complications among people with diabetes (Shivashankar et al., 2016; Medscape, 2017).

The result of this study showed that individuals with normal HbA1c (which suggested normal glycemic control) within the previous 3 months, had less incidence of cardiovascular disease, diabetic retinopathy, diabetic nephropathy, and diabetic neuropathic foot ulcers. Nonadherence to medication among diabetic patients is alarming (Blackburn et al., 2013). My data analysis showed that a greater number of the individuals reported low adherence to treatment which was congruence to their measured HbA1c levels.

According to UKPDS (2018), it is essential to control glucose levels in order to prevent hyperglycemia. Sustained and controlled hyperglycemia seriously damages the nerves, blood vessels, and subsequently the major organs. These major organs may include: eye (retinopathy), kidney (nephropathy), foot diseases (diabetic foot ulcers) increased risk of heart attacks (cardiovascular diseases), and/or strokes. My data analysis showed that low levels of adherence to treatment correlates well with cardiovascular disease, diabetic retinopathy, diabetic nephropathy and diabetic neuropathic foot ulcer after controlling for age and gender.

Interpretation of the findings

Age and diabetic complication

Age was controlled in this study; however, results of this study revealed that age consistently correlate with all diabetic complications (cardiovascular disease, retinopathy, diabetic nephropathy, and diabetic neuropathic foot ulcers). Data analysis showed that as individuals advance in age the severity of diabetic complications increased. Advanced aged individuals had more diabetic complications than the younger population. This finding may be due to prolonged uncontrolled hyperglycemia.

Gender and diabetic complication

Gender was also controlled in this study and results indicated that gender was statistically insignificant contributor to change in outcomes observed. The result of my data analysis showed that being male or female does not increase the severity of any diabetic complications.

HbA1c (glycemic control) and diabetic complication

Results from numerous studies have shown that nonadherence to antidiabetic medications makes the treatment of diabetes difficult and worsens diabetic complications (WHO, 2017). According to Fischer (2017), the goal of antidiabetic medication is to keep HbA1c within the normal range. The results of this study revealed that high levels of HbA1c indicating poor glycemic control increased the severity of all diabetic complications (cardiovascular disease, diabetic retinopathy, diabetic nephropathy, and diabetic neuropathic foot ulcer). Nearly all the individuals with normal HbA1c were not diagnosed and they did not report of any diabetic complications.

Adherence level and diabetic complication

According to Wilks et al. (2009), results from the 2007/8 JHLS revealed that only 40% of diabetics in Jamaica adhered to their antidiabetic medication, while 60% were nonadherent. Findings from my study concur with the findings by Wilks et al. (2009). My data analysis showed that majority of the people with diabetes reported low level adherence (nonadherence) to antidiabetic medication. Most of the nonadherent individuals had mild to severe diabetic complications.

Cardiovascular disease

The results from the data analysis for this study revealed that abnormally high levels of HbA1c were statically significant predictors of low levels of adherence to medication prescribed to treat diabetes. The theory of planned behavior has proven to be useful in predicting behavior such as adherence. Levels of adherence could be predicted based on consistent forms of attitude, subjective norm, perceived behavioral control,

intention, and previous behaviors (Rich et al., 2015). The WHO (2010) report states that people with diabetes have 2 to 3 times higher rates of cardiovascular disease than the general population and nonadherent behavior makes it worse. The results from this study revealed that majority of the patients that had experienced sustained uncontrolled hyperglycemia had mild to severe cardiovascular disease. This finding supported the findings of Amado et al. (2015) who suggested that nonadherence to treatment hinders a patient from achieving tight glycemic control, hence making the patient susceptible to diabetic complications. The outcome of this study also supported the findings by Papadakis et al. (2015), which indicated that cardiovascular myopathy among people living with diabetes was related to levels of adherence to treatment for diabetes.

Diabetic Retinopathy

Results from multiple regression analysis of this study revealed that abnormally elevated HbA1c levels were statistically significant predictors of the severity of diabetic retinopathy. This finding concurred with the finding of Wilks et al. (2009), who reported that JHLS revealed that most people with diabetes in Jamaica had diabetic retinopathy which was associated with nonadherence to treatment. The severity of diabetic retinopathy increased as abnormal HbA1c levels increased indicating poor glycemic control. The outcome of my data analysis confirmed the finding of WHO (2010), which suggested that the prevalence and severity of diabetic retinopathy among individuals with diabetes who have poor glycemic control is high. This finding is also the same as the findings of Khaw, Shah, and Elkington (2010), which suggested that diabetic retinopathy is a consequence of long period of uncontrolled glucose level.

Diabetic Nephropathy

The findings of this study indicated that HbA1c and levels of adherence to treatment had significant predictive relationship with diabetic nephropathy. According to Woldu et al. (2014) people with diabetes who poorly control their blood glucose are at greater risk of developing diabetic vascular complications that results in end organ damage, particularly, the kidney (diabetic nephropathy), heart (cardiomyopathy), and eyes (retinopathy). Medscape (2017) indicated that diabetic nephropathy is caused by persistent hyperglycemia that leads to renal injury. The findings in this study indicated that as abnormally high HbA1c increased, the severity of diabetic nephropathy increased, and as level adherence decreased, the severity of diabetic nephropathy increased. These findings supported the hypothesis that there is a predictive relationship between poor glycemic control (high levels of HbA1c and nonadherence) and diabetic nephropathy. The findings of this study confirmed the findings by Chang et al. (2015) that suggested that patient nonadherence to antidiabetic medication puts a patient at higher risk of developing end-stage renal disease (ESRD) when compared to patients who adhered to antidiabetic medication.

Diabetic Neuropathic Foot Ulcer

Results obtained from the multiple regression data analysis for this study explicated that abnormally high HbA1c levels were statically significant predictors of low-level adherence to antidiabetic medications prescribed to treat diabetes.

The result of data analysis revealed that low level adherence to antidiabetic medication was associated with mild to severe diabetic neuropathic foot ulcer. This

finding supported the finding of WHO (2017) that suggested that the prevalence of diabetic neuropathic foot ulcer is high, and it is directly associated with nonadherence to antidiabetic medications. Mayo clinic (2017) also affirmed that diabetic neuropathic foot ulcer is a late sequalae of diabetic complication caused by prolonged sustained hyperglycemia due to nonadherence to treatment. This study has revealed that HbA1c an indicator of poor glycemic control was significant predictor of the severity of diabetic neuropathic foot ulcer.

Limitations of the Study

The data used for this study were collected at only one general hospital located in a small town hence, a limitation to generalization of the outcome to the society at large. The level of adherence was self-reported by the patients in response to Morisky-8 item medication adherence scale questionnaire, as a result there may be issues regarding trustworthiness. However, HbA1c was a significant predictor of level of adherence for this study hence resolving questions regarding validity and reliability of the study outcome.

There are other factors that could potentiate complications among people with diabetes such as sedentary lifestyle, smoking cigarettes, obesogenic diet options, advanced age, late or undiagnosed diabetes mellitus, and the use of complementary or alternative medicine (Gemeay et al., 2015; Papadiski, 2015). These possible potentiating factors are all beyond the scope of this study and hence were not measured. It is also beyond the scope of this study to explore interventions that may enhance adherence among the target group.

Recommendations

The results of this study have revealed that low adherence (nonadherence) to antidiabetic medication has a significant predictive relationship with diabetic complications (cardiovascular disease, diabetic retinopathy, diabetic nephropathy, and diabetic neuropathic foot ulcer). Therefore, I recommend further studies on the predictive relationship between HbA1c and diabetic complications to expand the body of knowledge. It is also important to study how to improve adherence among this targeted populations while exploring factors affecting levels of adherence among diabetics in Jamaica. In addition, Ferguson, Tulloch-Reid, and Wilks (2010) suggested that there are few data addressing nonadherence and diabetic complications in the Caribbean region. Hence, I recommend for more extensive studies in this area as such data may be essential in planning effective strategies to combat the alarming prevalence of diabetes and its complications in the region.

Implications of the Study

The implications of this study will be far reaching. Analysis of data from this study had shown that low level adherence to antidiabetic medication continues to be a significant public health challenge with high burden of diabetic complications. I expect the outcome of this study to have positive effects at the individual level, family level, hospital level and could stir up conversations about the benefits of medication adherence and the traumatic consequences of nonadherence among the policy makers.

Positive Social Change, Theoretical and Empirical Implications

The potential for positive social change at the individual level, will include an adherent behavioral modification that may translate into tight glycemic control as well as decreased severity of diabetic complication. The positive impact at the family level, may include a healthier, happier and more productive family. At the organizational level, diabetics that are adherent to their treatment are less likely to call off sick. Most performance rating of healthcare facilities rely heavily on patient medication adherence. When patients adhere to treatment plan readmission are reduced to a bearable minimum.

The outcome of this study has the potential to form the basis for serious discussions among policy makers that could result in policies that could lend support to diabetics in Jamaica. There are also methodological, and empirical implications of this study; the methodology used in this study were already validated and used many times in the past. However, the outcome of this study when published will add to few empirical data available in the Caribbean region. further scientific investigations in this area, factors affecting the prevalence of nonadherence in Jamaica and ways to improve adherence among the target population. This study also has the implication for further scientific investigations that may broadly exploring factors affecting nonadherence in Jamaica and ways to improve adherence among the targeted population.

As shown in this study, HbA1c is a significant predictor of levels of adherence and has strong relationship with diabetic complications. Therefore, I recommend that health care providers should find creative ways to get their patients to take their medications as prescribed. Health care providers should adopt a shared-responsibility

approach; an approach that involves individual patients and their immediate families in the plan of care, particularly medication adherence.

The American Diabetes Association (ADA) has clinical practice guideline recommendations regarding the standards of medical care for management of diabetes, which are updated regularly based on best available empirical data. Most recently updated in 2018, these ADA guidelines are resources that health care providers must follow to deliver optimal quality of care for improved patient clinical outcomes. It is true that effective management of diabetes that prevents complications is an arduous task since it influenced by behavior and complicated by social and economic conditions of the patient. It is my recommendation that all these issues be addressed as part of the initial plan of care.

Conclusion

Diabetes mellitus is a chronic, debilitating metabolic disease that targets multiple organs, and has tremendous social and economic consequences. Due to the extensive debilitating nature of the disease, there is an obvious expectation on the part of the health care providers that patients will take their life and health seriously by taking their medications as prescribed. However, when the health seeking behavior of a patient lacks congruence with this expectation, there is always colossal traumatic consequences. In this research I found that nonadherence to antidiabetic medications has significant predictive relationship with diabetic complications. The severity of diabetic complications such as cardiovascular diseases, diabetic retinopathy, diabetic nephropathy, and diabetic neuropathic foot ulcer increases as abnormally high levels HbA1c increases.

Given the outcome of this study, I can suggest that tight glycemic control as evidenced by normal HbA1c, decreases the incidence and severity of diabetic complications. This finding supports American Diabetes Association's guideline for management of diabetes mellitus in which they recommend that HbA1c levels should be controlled at 7.0% or lower in other to prevent diabetic complications. Tight glycemic control is achieved only by strict adherence to treatment plan. Adherence to prescribed medications coincides with adequate motivation to adapt to lifestyle that integrates medication as part of activities of daily living.

Non-adherent behavior could be predicted according to the theory of planned behavior by considering an individual's beliefs about antidiabetic medications, perceived severity of diabetes and its complications, and knowledge about the benefits of adhering to antidiabetic medications which outweighs the risk of potential side effects, minor discomforts, and even the cost of the medication (Van Camp, Bastiaens, Van Royen, & Vermeire, 2016). All health care providers should pay attention to the predictive adherent behaviors of their patients and know the best corrective measures to apply in other to achieve optimal treatment, hence reduce diabetic complications.

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Appendix A: Title of Appendix