Correlates of Diabetes Self-Care Behaviors in Adults with Type 2 Diabetes and Comorbid Heart Failure

By Fekadu Aga

Dissertation for the Degree of Doctor of Philosophy (PhD) in Nursing, Addis Ababa University, Ethiopia

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Abstract

Background: Effective performance of diabetes self-care behaviors in type 2 diabetes (T2D) is crucial for improving glycemic control and managing diabetes-related comorbidities including heart failure (HF). Compared to persons without T2D those with T2D have 2-3 fold higher incidence of comorbid HF which often result in increased morbidity and poorer survival. Little is known, however, about the correlates of diabetes self-care behaviors and outcomes in people with T2D and comorbid HF.

Objective: The purpose of this secondary analysis study was to provide a deeper conceptual understanding of the correlates of diabetes self-care behaviors in adults with T2D and comorbid HF.

Methods: Baseline data of 180 participants from a randomized clinical trial that tested a 6-month integrated self-care intervention for adult persons with comorbid HF and T2D were analyzed. Study-developed data extraction forms and a battery of standardized instruments were used to collect demographic, clinical, and psychosocial data from medical records and self-report. Diabetes self-care behaviors were measured using the Summary of Diabetes Self-Care Activities (SDSCA). Glycated hemoglobin (HbA1c) and fasting blood glucose (FBG) were analyzed from whole blood sample at baseline. Correlational bivariate, multiple logistic regression and hierarchical linear regression analysis were performed to examine associations and predictors of diabetes self-care behaviors and glycemic control. The IBM SPSS for Windows version 24 was used to analyze the data.

Result: The participants mean age was 58.1±10.7 years and the majority were male (n = 118, 65.6%) and African American (n = 119, 66.1%). Good self-rated health and presence of an implantable cardioverter defibrillator ($p < 0.01$) predicted better diabetes self-efficacy while taking both oral antiglycemic medication and insulin, history of depression, cardiac pacemaker, and digitalis ($p < 0.05$) predicted lower diabetes self-efficacy. Number of comorbidities >2 ($p<0.001$), having more than a high school education ($p< 0.05$) and African American ethnicity ($p< 0.05$) predicted better exercise, blood glucose testing, and foot care behaviors, respectively. The use of an aldosterone inhibitor($p< 0.05$) predicted worse exercise performance, higher Charlson comorbidity index scores ($p< 0.01$) predicted worse SMBG, and treatment with diet plus medication ($p< 0.05$) and dyslipidemia ($p< 0.001$) predicted worse foot care behaviors. In a bivariate analysis, the SDSCA general diet ($p = 0.036$) and SDSCA exercise ($p = 0.029$) were negatively associated with HbA1c, while SDSCA specific diet ($p = 0.047$) was positively associated. None of the diabetes self-care behaviors emerged as independent predictors of either HbA1c or FBG in the regression models. Diabetic-end organ failure, taking insulin only, taking oral antiglycemic and insulin, African American race, and dyslipidemia predicted higher HbA1c values ($p< 0.05$). Years since diagnosis of HF ($p< 0.05$), taking insulin ($p< 0.01$), diabetic-end organ failure ($p< 0.01$), and total daily medications ($p< 0.05$) predicted higher FBG values.

Conclusion: This study identified demographic, clinical, and psychosocial factors associated with diabetes self-care behaviors and with diabetes self-efficacy. Nevertheless, the diabetes self-care behaviors' lack of influence of HbA1c and FBG is a major finding of this study. This underscores that the conventional disease-specific approach to diabetes self-care intervention cannot help to improve patient outcomes in people with T2D and comorbid HF. Therefore, it is imperative to shift from disease-specific approach to integrated diabetes self-care model to improve outcomes for this population.

Abbreviations

AADE	American Association of Diabetes Educators
ACE	Angiotensin-converting enzyme
ADA	American Diabetes Association
ANOVA	Analysis of variance
ARB	Angiotensin receptor inhibitors
BCST	Blessed Cognitive Screening Tool
CABG	Coronary artery bypass grafting
CCI	Charlson comorbidity index
CDC	Center for Disease Control and Prevention
CVD	Cardiovascular disease
DM	Diabetes mellitus
DMKT	Michigan Diabetes Knowledge Test
ESSI	ENRICHD Social Support Instrument
FBG	Fasting blood glucose
GDP	Gross Domestic Product
HbA1c	Glycated hemoglobin
HF	Heart Failure
ICD	Implantable cardioverter defibrillator
IDF	International Diabetes Federation
IRB	Institutional Review Board
LVEF	Left ventricular ejection fraction
MD	Mean difference
NCD	Noncommunicable Disease

NCD-RisC	Noncommunicable Disease Risk Factor Collaboration
NYHA	New York Heart Association
OD	Odds Ratio
PCI	Percutaneous coronary intervention
PDSMS	Perceived Diabetes Self-Management Scale
PHQ-9	Patient Health Questionnaire-9
PTCA	Percutaneous transluminal coronary angioplasty
SD	Standard deviation
SDSCA	Summary of Diabetes Self-Care Activities
SMBG	Self-monitoring blood glucose
T1D	Type 1 diabetes mellitus
T2D	Type 2 diabetes mellitus
WHO	World Health Organization

CHAPTER I

STATEMENT OF THE PROBLEM

Diabetes mellitus (DM) is one of the largest global health threats of the 21st century (Cho et al., 2018; Jaacks, Siegel, Gujral, & Narayan, 2016; Zimmet, Magliano, Herman, & Shaw, 2014).The International Diabetes Federation (IDF) estimated that about 425 million adults (20-79 years) were living with diabetes worldwide in 2017 and this number is expected to increase to 629 million by 2045 (IDF, 2017). The World Health Organization (WHO) and the Non-communicable Disease (NCD) Risk Factor Collaboration (NCD-RisC) gave a similar estimate of 422 million in 2014(NCD-RisC, 2016; WHO, 2016). More than 90% of all DM cases are Type 2 diabetes (T2D) which continues to increase in prevalence (Holman, Young, & Gadsby, 2015; G. Xu et al., 2018). DM is associated with an increased risk of premature mortality (IDF, 2017; WHO, 2016) social, economic and health system burden worldwide (Bommer et al., 2017; Cho et al., 2018). Patients with T2D also have a higher number of comorbid conditions (Iglay et al., 2016; Lang & Markovic, 2016; O'Shea, Teeling, & NBennet, 2013) which can result in poor glycemic control (Lang & Markovic, 2016), increased cost of treatment (Rui Li et al., 2013; O'Shea et al., 2013), and lower quality of life (Adriaanse, Drewes, Heide, Struijs, & Baan, 2016). About 50% of T2D patients face premature mortality from cardiovascular disease (CVD) complications including coronary artery disease, heart failure and stroke, and approximately10% from renal failure (Dieren, Bealens, Schouw, Grobbee, & Neal, 2010).

Heart failure (HF) is the most common and often the earliest indicator of CVD in people with T2D followed by peripheral arterial disease (Shah et al., 2015). Globally, 14.9% of people with T2D have comorbid HF (Einarson, Acs, Ludwig, & Panton, 2018) which is much higher than the prevalence of HF (1-12%) in the general population (Roger, 2013). The existence of comorbid HF in people with T2D is associated with increased morbidity and poorer survival rates (Bauduceau, Floch, Halimi, Verny, & Doucet, 2018).

Diabetes self-care in adults with T2D is essential for achieving diabetes control, successful disease management and improvement of disease-related health outcomes. Performing optimal diabetes self-care behaviors are often associated with improved quality of life, reduced cost of care, better control of glycated hemoglobin (HbA1c), reduced healthcare utilization and improved control of cardiovascular risk factors (Shrivastava, Shrivastava, & Ramasamy, 2013; Song, Ratcliffe, Tkacs, & Riegel, 2012; Tshiananga et al., 2012). The American Association of Diabetes Educators (AADE) characterized diabetes self-care as engagement in the recommended behaviors for diet, physical activity, medication adherence, blood glucose monitoring, problem solving, symptom recognition and management, foot care, healthy coping and risk reduction (AADE, 2008). However, many patients face challenges in implementing the recommended diabetes self-care behaviors. For example, one study showed that 84.8% of T2D patients do not exercise, 35.7% consume high-fat diet, 53.5% consume high-sugar diet and 51% do not self-monitor blood glucose. In contrast, 95.7% were reported to adhere to the medication regimen for T2D and 77.4% performed foot care routinely(Daoud, Osman, Hart, Berry, & Adler, 2015). Other studies report similar findings (Ortiz et al., 2016; Ouyang et al., 2015). Antecedents such as demographic, clinical, psychosocial, and environmental factors can influence successful performance of diabetes self-care behaviors in people with T2D (Ahola & Groop, 2013; Harwood, Bunn, Caton, & Simmons, 2013; Shrivastava et al., 2013). When there is another serious comorbid condition such as HF, antecedent factors may play a more robust role in the ability of an individual to perform diabetes self-care effectively and achieve glycemic control.

Purpose of the Study

Previous research has been disease-specific and provides little direction for self-care for people with T2D in the presence of other serious comorbid conditions. This study was informed by the findings of a systematic review that examined the role of diabetes-concordant and discordant chronic conditions on the performance of self-care behaviors in adults with T2D (Aga, Dunbar, Kebede, & Gary, 2019). The review showed that HF is the least frequently measured T2D concordant comorbidity in relation to diabetes self-care behaviors. Thus, little is known about the antecedents of diabetes self-care behaviors in people withT2Dand comorbid HF. In addition, the relationship between diabetes self-care behaviors and glycemic control in people with T2D and comorbid HF is not well understood. Understanding these relationships is essential for designing effective self-care interventions for persons with T2D and comorbid HF in order to optimize health outcomes. Therefore, the purpose of this secondary analysis study was to provide a deeper conceptual understanding of the correlates of diabetes self-care behaviors in adults with T2D and comorbid HF. This study was a cross-sectional, correlational design using baseline data from a randomized study that tested a 6-month integrated self-care intervention in 180 adults with concomitant HF and T2D (Dunbar et al., 2014; Dunbar et al., 2015).

Specific Aims:

Aim 1: Characterize the sociodemographic and clinical correlates of diabetes self-efficacy in adults with T2D and comorbid HF.

Aim 2: Describe the correlates of diabetes self-care behaviors in adults with T2D and comorbid HF.

Aim 3: Determine the relationship between diabetes self-care behaviors and glycemic control in adults with T2D and comorbid HF.

These aims helped to identify factors correlated and predict diabetes self-care behaviors and self-efficacy in adults with T2D and comorbid HF. Findings from this study provided important insights that are essential for designing self-care interventions for people with T2D and comorbid HF.

BACKGROUND AND SIGNIFICANCE

Definition and Classification of Diabetes

Diabetes mellitus (DM), which results from either impaired insulin secretion or impaired insulin action or both, refers to a group of metabolic disorders that contribute to chronic hyperglycemia (Petersmann et al., 2018). DM is commonly classified as type 1 diabetes (T1D), type 2 diabetes (T2D), gestational diabetes, and other specific types of diabetes (ADA, 2019a; Petersmann et al., 2018). The classifications used to categorize DM is primarily based on the pathophysiologic process that cause hyperglycemia (Blaslov, Naranda, Kruljac, & Renar, 2018). T1D is characterized by absolute insulin deficiency resulting from β-cell destruction whereas T2D is depicted as a progressive loss of β-cell insulin secretion in conjunction with insulin resistance. Gestational DM refers to a glucose tolerance impairment that is first diagnosed during pregnancy. Pancreatitis, cystic fibrosis, Cushing's syndrome, infections and genetic defects of the β-cell function or insulin action are other disease specific reasons for the development of diabetes. Classification of T1D and T2D is important for treatment decisions though some individuals cannot be precisely identified as having T1D or T2D upon diagnosis (ADA, 2019a).

Pathophysiology of Diabetes

Underlying the pathophysiology of DM is inadequate carbohydrate metabolism and insulin function. Insulin is a peptide hormone produced by the β-cells of the pancreatic islets of Langerhans and the main anabolic hormone that regulates the metabolism of carbohydrates, fats, and protein (Dimitriadis, Mitrou, Lambadiari, Maratou, & Raptis, 2011). It performs this function by facilitating the absorption of glucose from blood stream into liver, fat, and skeletal muscle cells; and stimulating the storage of excess glucose in the form of glycogen. When blood glucose is high the β-cells secrete insulin and when blood glucose is low secretion of insulin is inhibited. Thus, the occurrence of DM is primarily related with problem in β-cell mass and function that affects insulin secretion (Skyler et al., 2017).

Hyperglycemia resulting from pancreatic β-cell destruction or dysfunction is a common factor in the different types of DM (Skyler et al., 2017). T1D is an autoimmune disorder characterized by the destruction of insulin-producing β-cells. Glucose-specific insulin secretory defect and insulin resistance are central to pathophysiology of T2D (Skyler et al., 2017; Zaccardi, Webb, Yates, & Davies, 2016). Hyperglycemia in conjunction with polyuria, polydeipsia, and polyphagia also known as the 3 P's – are the main symptoms of DM. Chronic hyperglycemia may also lead to blurred vision and increased susceptibility to infections. It may also result in weight loss in T1D and neuropathy in T2D. Considering all categories of DM, 5 to 9% are T1D and more than 90% are T2D (Holman et al., 2015; G. Xu et al., 2018).

Diagnosis of Diabetes

Hyperglycemia induced oxidative stress increases the risk of developing both CVD and non-CVD complications in people with all forms of DM (Pitocco, Tesauro, Alessandro, Ghirlanda, & Cardillo, 2013). Accurate and early diagnosis contributes to the efforts to prevent these complications. The American Diabetes Association (ADA) suggests that fasting blood glucose (FBG), the 2-hour plasma glucose (2-h PG) during a 75 gram oral glucose tolerance test (OGTT), and glycated hemoglobin (HbA1c) are equally valuable tests for the diagnosis of DM (ADA, 2019a). Thus, the diagnosis can be based on FBG ≥ 126 mg/dL (7.0 mmol/L), 2-h PG ≥ 200 mg/dL (11.1 mmol/L), or HbA1c ≥ 6.5% (48 mmol/mol). Antibody testing to identify the presence of one or more autoimmune markers was also suggested for defining T1D (ADA, 2019a).

Management of Diabetes

Self-care along with pharmacological therapy is the cornerstone for DM management. As recommended in the current guidelines, those with DM should participate in diabetes self-management education in order to enhance their knowledge, skills and self-efficacy required for effective diabetes self-care (ADA, 2019b; Beck et al., 2017). Diabetes self-management education and support should be patient-centered in order to address the needs, preferences and goals of DM patients (ADA, 2019b; Beck et al., 2017). Diabetes self-management education and support improves glycemic control, quality of life, self-care behaviors and self-efficacy. In addition, reduction in health service utilization and costs, lower blood pressure, body weight and all-cause mortality are also associated with effective performance of diabetes self-care (Al-Khaledi et al., 2018; Aminuddin, Jiao, Jiang, Hong, & Wang, 2019; Azami et al., 2018; He et al., 2017; Saslow, Summers, Aikens, & Unwin, 2018; Strawbridge, Lloyd, Meadow, Riley, & Howell, 2017).

Since there is no production of endogenous insulin hormone, persons with T1D should be initiated on insulin treatment immediately upon diagnosis (McGibbon, Adams, Ingersoll, Kader, & Tugwell, 2018). Treatment with multiple daily injections of prandial and basal insulin or continuous subcutaneous insulin infusions is recommended for T1D (ADA, 2019d; McGibbon et al., 2018). Rapid-acting insulin analogs rather than short-acting (regular) insulin is recommended because of higher risk for hypoglycemia with the latter type (ADA, 2019d). Patient education is also important to help match prandial insulin doses to carbohydrate intake, pre-meal blood glucose level, and anticipated physical activity(ADA, 2019d). Though consensus is lacking to guide selecting the best form of insulin administration (Pickup, 2013), a recent meta-analysis showed that in both adults and children with T1D continuous subcutaneous insulin infusion compared to multiple daily injections was associated with significant reduction of HbA1c but no difference in incidence of hypoglycemia and ketoacidosis (Benkhadra et al., 2017; Qin, Yang, Huang, Chen, & Yao, 2018).

The goals of treatment for T2D are to prevent or delay the incidence of complications and maintain quality of life through optimum glycemic control, CVD risk management, regular follow-up and a patient-centered approach to enhance engagement in self-care behaviors (Chaudhury et al., 2017; Davies et al., 2018). Concerning drug treatment, metformin is a first line medication and should be started at the time of T2D diagnosis, unless contraindicated, supported with self-management education and support to bring about engagement in self-care behaviors that lead to lifestyle modifications (ADA, 2019d; Chaudhury et al., 2017). Early initiation of drug treatment after diagnosis of T2D can greatly prevent irreversible microvascular complications such as retinopathy and nephropathy (Bailey, 2015). Though metformin should be continued provided that it is tolerated and there is no contraindication, its long-term use can cause vitamin B_{12} and folic acid deficiency (ADA, 2019d; Chaudhury et al., 2017). Thus, there should be periodic measurement of vitamin B12 and folic acid levels in bloods of metformin-treated patients, especially in anemic, peripheral neuropathic and elderly patients. Evidence of continuous weight loss and symptoms of hyperglycemia (HbA1c > 10%) should guide the consideration to initiate insulin treatment and newly diagnosed T2D patients with HbA1c ≥ 1.5% above their glycemic targets be taken as candidates for dual therapy (ADA, 2019d). A patient-centered approach that involves considering patients preferences, individualized glycemic target, comorbidities, risk for side effects, cost effectiveness, risk for hypoglycemia and impact on weight should guide the selection of antiglycemic medications (ADA, 2019d; Chaudhury et al., 2017; Davies et al., 2018). Health providers should reevaluate the drug regimen every 3 to 6 months and the required adjustment with changing health status (ADA, 2019d).

Prevalence and Burden of Diabetes

Diabetes mellitus is rapidly growing globally that contributes to poor health outcomes and considerable socioeconomic burden to individuals, families and society (Cho et al., 2018; IDF, 2017; Jaacks et al., 2016; NCD-RisC, 2016; WHO, 2016; Zimmet et al., 2014). The increasing prevalence is mainly attributable to the global epidemic of T2D (Jaacks et al., 2016; Unnikrishnan, Pradeepa, Joshi, & Mohan, 2017) that also constitutes more than 90% of all DM cases (Holman et al., 2015; G. Xu et al., 2018). Factors deriving the development of T2D include lifestyle behaviors such as sedentary lifestyle, physical inactivity, smoking, alcohol consumption, dietary patterns, and genetic influences (Mutie, Giordano, & Franks, 2017; Y. Wu, Ding, Tanaka, & Zhang, 2014; Zimmet, 2017; Zimmet et al., 2014). The impact of the intra-uterine environment and epigenetic changes are also suggested as future risks of T2D in adults (Zimmet, 2017; Zimmet et al., 2014). Some studies also show that change in human gut microbiome and vitamin D deficiency (Y. Wu et al., 2014) and infections that precipitate insulin resistance (Chakraborty, Bhattacharyya, & Banerjee, 2017)can be risk factors for T2D .

The global age-standardized prevalence of all type of DM is 9.0% in men and 7.9% in women although there is great regional variation (NCD-RisC, 2016). The IDF age-adjust comparative DM prevalence estimate shows 11.0% in North America and Caribbean followed by 10.8% in Middle East and North Africa, 10.1% in South-East Asia, 8.6% in Western Pacific, 7.6% in South and Central America, 6.8% in Europe, and 4.4% in Africa among 20 to 79 year old adults in 2017 (IDF, 2017). China, India and the United States were countries with the largest number of adult people with DM in 2017 (IDF, 2017). The Center for Disease Control and Prevention (CDC) report shows that 29.1 million (9.3%) people live with DM in the United States (CDC, 2014). A study also indicated that because of the continued increase in its prevalence, DM remains a major cause of disease burden in the US despite a significant decrease in the rates of diabetes-related complications (Gregg et al., 2014).

Contrary to the traditional understanding of DM as a disease of affluent countries, current trends indicate that its prevalence is rising at alarming rates in low-and middle-income countries compared to high-income countries (Cho et al., 2018; IDF, 2017; Jaacks et al., 2016; NCD-RisC, 2016; WHO, 2016; Zimmet et al., 2014). In the coming decades, Africa is anticipated to have a large increase in DM largely due to demographic, sociocultural, and economic transitions underlying uncontrolled urbanization, nutrition transition, and physical inactivity (Atun et al., 2017; Peer, Kengne, Motala, & Mbanya, 2014; Werfalli, Engel, Musekiwa, Kengne, & Levitt, 2016).

With scarce resources and a weak healthcare system, Ethiopia is estimated to have more than 2.5 million adults (20 to 79 years) living with DM (IDF, 2017). The national prevalence for DM in Ethiopia is uncertain however, due to the lack of a national disease surveillance or registry system. Nevertheless, a recently published national survey in Ethiopia showed a DM prevalence of 3.2%, impaired fasting glucose of 9.1% with ADA criteria and 3.8% with WHO criteria, and metabolic syndrome occurring in 4.8% of the population (Gebreyes et al., 2018). This conflicts with a number of studies reporting higher rates of DM in various subpopulations in Ethiopia including 6.5% among bank employees and school teachers in Addis Ababa (Nshisso et al., 2012), 5.1% in urban locations and 2.1% in rural settings in the North West of the country (Abebe, Berhane, Worku, & Assefa, 2014) In addition, 7% were reported to have DM among government employees in the east (Ayana, Bacha, Roba, & Kebede, 2015), 8% among HIV/AIDS patients in the south (Sachithananthan, Loha, & Gose, 2013), and 8.3% in tuberculosis patients in south eastern Amhara region (Workneh, Bjune, & Yimer, 2016).

T2D and its complications pose high health and economic burden worldwide. For instance, the Global Burden of Disease Study (GBDS) in 2017 identified that DM caused 1.37 million deaths in 2017 of which 74.8% were from T2D (GBD, 2018a). The GBDS also indicated that the total death from T1D increased from 2007 to 2017 by 15.1% while that from T2D by 43.0%. Within this time period, mortality from T1D decreased by 11.0% whereas that from T2D increased by 5.9% (GBD, 2018a). The global disability adjusted life year (DALY) due to DM in 2017 was 67.9 million, to which T1D contributed 10.4 million and T2D 57.4 million DALY (GBD, 2018b). The overall DM-related DALY increased from 2007 to 2017 by 30.0%, from which T1D constituted 11.5% and T2D 34.0% (GBD, 2018b). Studies also show that DM causes a substantial global economic burden that affects individuals, families, and the health care system (Bommer et al., 2017; Cho et al., 2018; IDF, 2017; WHO, 2016). For instance, Bommer and colleagues (2017) estimated the global cost of DM for 2015 in US$ as 1.31 trillion which constituted 1.8% of the global gross domestic product (GDP). These authors also noted that indirect cost comprised 34.7% of the total burden and North America was the largest contributor to global cost and the most negative influence on GDP. They also indicated that DM related costs also affect poorer world regions though limited data is currently available for low-income and middle-income countries.

Diabetes and Comorbidities

The rate of comorbid conditions, the presence of other serious chronic diseases, is alarmingly high in DM patients worldwide. Studies have shown a median of 5 comorbidities among the elderly population with T2D in Australia (Caughey et al., 2010) and Ireland (O'Shea et al., 2013), at least one comorbid condition in 97.5% and two in 85.5% of T2D patients in the US (Iglay et al., 2016), and 77.7% in Croatian T2D patients (Lang & Markovic, 2016). The most prevalent T2D comorbidities, according to these studies, are cardiovascular diseases, hyperlipidemia, chronic kidney disease, retinopathy, musculoskeletal disorders, depression, and connective tissue diseases. Studies also report that low socioeconomic status, obesity and job strain (Ervasti et al., 2016), and race/ethnicity (Lopez, Bailey, & Rupnow, 2015; Mehta et al., 2011) are associated with an increased prevalence of comorbidity in T2D. Particularly, hypertension and retinopathy are said to be more common in blacks and Hispanics compared to whites with T2D (Lopez et al., 2015). The number of comorbid conditions in T2D may also rise with increasing age (Lang & Markovic, 2016; Lopez et al., 2015).

Comorbid conditions in DM pose various challenges for treatment and health outcomes. Studies indicate that the existence of comorbid conditions in T2D make treatment selection very difficult (Caughey et al., 2010; Hollander & Kushner, 2010; Huang, 2016; Iglay et al., 2016). One study showed that 22.7% of elderly DM patients with comorbidities were offered at least one potentially inappropriate medicine while 16% were dispensed a medicine that had known adverse effects (Caughey et al., 2010). Another study indicates the existence of a significant negative association between physicians' reluctance to prescribe treatmentinT2D and other comorbidities (Lang & Markovic, 2016). The presence of comorbid conditions affects long-term DM control parameters such as glycated hemoglobin (HgA1c) and blood pressure (Lang & Markovic, 2016; Leong, Banerjee, Nolen, Adab, & Thomas, 2014; Luijks et al., 2015; Magnan, Palta, Mahoney, et al., 2015). However, the effect may vary with the numbers and types of comorbid conditions, age, gender and socioeconomic status (Lang & Markovic, 2016; Luijks et al., 2015), and ethnicity(Mehta et al., 2011).

Patients with more diabetes-concordant comorbidities, defined as illnesses that share the same pathogenesis and management plans with DM (e.g., heart failure, hypertension), may have better glycemic control compared to those with diabetes-discordant comorbidities (Aung et al., 2015; Magnan, Palta, Johnson, et al., 2015; Pentakota et al., 2012; Ricci-Cabello et al., 2015). The presence of diabetes-concordant comorbidities may cue health care providers' to render the same care required for diabetes management and this can subsequently enhance glycemic control (Magnan, Gittelson, et al., 2015; Voorham et al., 2012). Comorbid conditions in DM are also associated with increased cost of care (Huber, Diem, Schwenkglenks, Rapold, & Reich, 2014; Rui Li et al., 2013; O'Shea et al., 2013). A study from Switzerland shows that DM patients with more than two comorbidities expended as much as US$10,584 higher total costs compared to those without comorbidity in 2011, and the cost was significantly higher for those with comorbid cardiovascular diseases, hyperlipidemia, hyperacidity disorders, and pain (Huber et al., 2014). Studies have also shown that comorbidities in T2D may affect the quality of life of patients(Adriaanse et al., 2016; Wermeling, Gorter, Stel, & Rutten, 2012). It is evident from these studies that T2D patients with comorbidities have lower physical and mental health functioning. In particular there is a significant, inverse relationship between the number of comorbid conditions and physical and mental health functioning among persons with DM, but is more evident in the physical components of quality of life (Adriaanse et al., 2016; Wermeling et al., 2012). Furthermore, DM patients with comorbid conditions such as mental, musculoskeletal, cardiovascular, and nervous system disorders likely experience significantly higher work disability (Ervasti et al., 2016; Virtanen et al., 2015).

Type 2 Diabetes and Heart Failure Comorbidity

Heart failure (HF) is one of the common CVD comorbidities in T2D that results in poorer clinical outcomes. The American Heart Association (AHA) and American College of Cardiology (ACC) defined HF as "a complex clinical syndrome that results from any structural or functional impairment of ventricular filling or ejection of blood" (Yancy et al., 2013). DM and HF, which are concordant comorbid diseases, are bidirectionally linked, each disease independently increasing the risk for the other and leads to a poorer prognosis than with either disease alone (Cas et al., 2015; Khan, Butler, & Gheorghiade, 2014; Lombardi, Spigoni, & Dei-Cas, 2016).

Globally, 14.9% of people with T2D have comorbid HF (Einarson et al., 2018) which is higher than the prevalence of HF (1-12%) in the general population (Roger, 2013). Compared to peripheral arterial disease, HF was indicated as the most common initial manifestation of CVD in T2D (Shah et al., 2015). An earlier Framingham Heart Study indicated that the risk of developing HF in DM patients is 2.4-fold higher in men and 5-fold higher in women compared to non-DM patients (Kanne, Hjortland, & Castelli, 1974). In addition, the Saskatchewan Health study reported that in recent onset T2D the risk of incident HF was 3.3-fold higher in men and 2.5-fold higher in women compared to the general population (Leung et al., 2009). The incidence rate of HF in people with T2D is significantly higher than those without DM (30.9 and 12.4 case per 1000 person-years) with the rate ratio of 2.5, 95%CI: 2.3, 2.7 (Nichols, Gullion, Koro, Ephros, & Brown, 2004).

Over 40% of hospitalized HF patients have DM (Sarma et al., 2013). There is pronounced insulin resistance in patients with HF that can increase the risk of developing T2D that contributes to a worse prognosis (Riechle & Abel, 2016). People having both DM and HF have a 36% increased relative risk for hospitalization (Kamalesh & Cleophas, 2009) and a hazard ratio (HR) of 31.5% for rehospitalization (Greenberg et al., 2007), 40% for the development of nonfatal myocardial infarction and 70% for nonfatal stroke (Cavender et al., 2015), and elevated risk of cardiovascular and all-cause mortality (Bauduceau et al., 2018; Cavender et al., 2015). Bertoni and colleagues (2004) demonstrated that DM patients who develop HF have a 10-fold increased risk of mortality and only 12.5% will be alive in 5 years compared to above 80% in those without HF.

In addition to the overall HF risk factors , T2D increases the likelihood of HF through increased risk of cardiomyopathy and coronary artery disease that result in structural and functional changes in the heart (Jia, Hill, & Sowers, 2018; W.-S. Lee & Kim, 2017).Thus, important risk factors for the development of HF in the DM population include advancing age, history of ischemic/coronary heart disease, higher BMI, longer years lived with DM, high blood pressure, and use of insulin (Bahtiyar, Gutterman, & Lebovitz, 2016; Bertoni et al., 2004; Cas et al., 2015; Nichols et al., 2004; Sarma et al., 2013; Wang, Negishi, Negish, & Marwick, 2015). A study that adjusted for confounders (gender, BMI, hypertension, and medications) indicated that coronary heart disease, HbA1c $\geq$ 10%, insulin use, HbA1c 9-10%, and a 5-year increase in age was strongly associated with incident HF in people with T2D (Wang et al., 2015). Poor glycemic control is also associated with increased risk of HF hospitalization in people with T2D (Bahtiyar et al., 2016; Blecker, Park, & Katz, 2016; Lind et al., 2012; Melle et al., 2010). For example, one study showed that for every1% increase in HbA1clevel >6.5% there is a 36% increased hazard ratio (HR) of hospitalization in patients with comorbid DM and HF(Melle et al., 2010). A Swedish National Diabetes Registry study shows that obesity is also strongly linked with increased risk of HF hospitalization in patients with T2D(Glogner et al., 2014). According to this study, using a BMI of 20 to < 25 Kg/m^2 as the reference group, the hazard ratios for hospitalization in the 10,969 hospitalized patients during a median follow-up of 7.2 years were significantly higher for those who had BMI ≥25 Kg/m^2.

The existence of HF comorbidity in T2D often makes the patient's self-care demand more complex. Though HF is a concordant comorbidity in T2D, their recommendations for self-care in diet, medications, and symptom management may become complex and sometimes competing(Cha, Clark, et al., 2012). For example, low carbohydrate and low sodium diet recommendations may work well for people with T2D-HF but the fluid restriction requirement for HF may be challenging because of high demand for fluid intake resulting from an increased glucose level. People with comorbid T2D and HF have poorer NYHA functional class, higher HF-related symptoms, lower quality of life, and worse exercise tolerance (Kristensen et al., 2017; Kristensen et al., 2016). In addition, HF is a progressive debilitating illness often resulting in frailty (Boxer, Shah, & Kenny, 2014) and cognitive impairment (Leto & Feola, 2014). Both frailty and cognitive impairment can have negative consequences on the ability to perform both diabetes and HF self-care. Optimal management of HF may delay the progression of worsening HF and improve an individual's ability to perform diabetes self-care.

Conceptual Framework

Diabetes self-care

The successful management of T2D requires a patient's engagement in self-care on a daily basis to control disease progression and prevent serious complications, reduce hospitalizations and improve quality of life(Adepoju et al., 2014; Shrivastava et al., 2013; M. Song et al., 2012; Tshiananga et al., 2012). In broader terms, self-care within the realm of chronic illness has been conceptualized as a behavioral process of decision-making and performing health-related activities to promote and maintain health, prevent disease, and manage symptoms by incorporating these activities in daily life patterns (Dunbar, Clark, Quinn, Gary, & Kaslow, 2008; Richard & Shea, 2011; Riegel, Jaarsma, & Stromberg, 2012; Sidani, 2011).

Consistent with Riegel & Dickson's situation-specific theory of heart failure self-care (Riegel & Dickson, 2008) others (Song, 2010; M. Song et al., 2012) have conceptualized diabetes self-care as involving maintenance and management. However, self-efficacy influences both the maintenance and management dimensions of self-care behaviors (Richard & Shea, 2011). Self-efficacy, the construct which was first introduced within Bandura's social cognitive theory, refers to a person's beliefs in own ability to plan and carry out a course of action in order to achieve a designated goal (Bandura, 1997). Therefore, characterizing the correlates of self-efficacy as it applies to a person's confidence about performing diabetes self-care behaviors in adults with T2D and comorbid HF was an important goal of this study.

Diabetes self-care maintenance encompasses the routine self-care activities such as monitoring of signs and symptoms and adherence to the recommended treatment regimen. Diabetes self-care management is the non-routine decision-making and activities undertaken in response to signs and symptoms. From this perspective, diabetes self-care management comprises five stages: (a) recognizing signs and symptoms (e.g., increased thirst, frequent urination, increased hunger, tiredness); (b) evaluating signs and symptoms; (c) deciding to take actions; (d) implementing treatment; and (e) evaluating treatment effectiveness. This framework is congruent with earlier conceptualizations of diabetes self-care decisions and activities as a dynamic process of responding to bodily cues that often influenced by a number of contextual factors such as a patient's experience, values, culture, risk perception, preferences, and support system(Hernandez, Bradish, Rodger, & Rybanaky, 1999; Paterson, Russell, & Thorne, 2001; B. L. Paterson & S. Thorne, 2000a, 2000b). Diabetes self-care involves engagement in multidimensional self-care behaviors including healthy eating, physical activity, blood glucose monitoring, medication taking, problem solving, and risk reduction (AADE, 2008; Beck et al., 2017; Shrivastava et al., 2013). The current study focused on the three dimensions of diabetes self-care behaviors (foot inspection, exercise, and blood glucose self-monitoring) as operationalized in the Summary of Diabetes Self-Care Activities Measure (Toobert, Hampson, & Glasgow, 2000). Diabetes self-care refers to a dynamic behavioral process as well as purposeful, active engagement in physical activity, blood glucose self- monitoring, and foot inspections that are influenced by personal, socioeconomic, and cultural context.

An integrated conceptual framework developed to guide HF self-care research was adapted as the conceptual framework for this study (Dunbar et al., 2008). The integrated conceptual framework pooled together concepts from self-management theories and learning theories used in patient education for self-care. The variables in the framework are structured around antecedents and outcomes of self-care behaviors. The antecedents in the conceptual framework are *individual characteristics* such as age, gender, ethnicity; *clinical characteristics* like illness severity, comorbidity, cognitive status; *behavioral characteristics* such as motivation, self-efficacy, depression; and the *knowledge and skills* required to perform the self-care behaviors.

The integrated conceptual framework (Dunbar et al., 2008) was modified for this study to reflect factors associated with diabetes self-care behaviors and outcomes (Figure 1). Based on a comprehensive review of the literature, the potential antecedents and outcomes of diabetes self-care behaviors were identified. The antecedents are demographic characteristics, clinical factors, and psychosocial factors including diabetes knowledge, depression, diabetes self-efficacy, and social support. The outcomes of diabetes self-care behaviors are two markers of glycemic control: glycated hemoglobin (HbA1c) and fasting blood glucose (FBG).

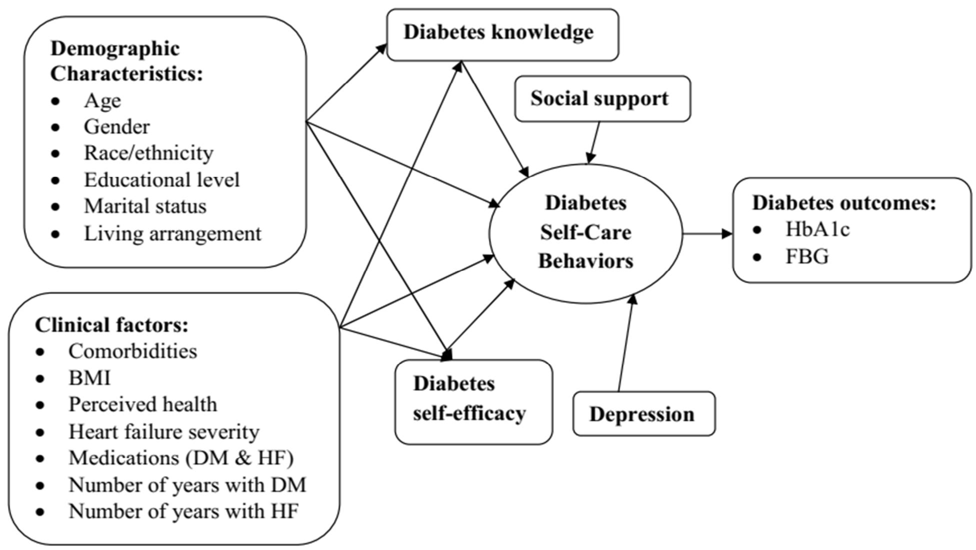

Figure 1-0-1. The conceptual model for diabetes self-care behaviors in adults with type 2 diabetes mellitus and comorbid heart failure. The model was adapted from the integrated conceptual framework for heart failure self-care research (Dunbar et al.2008)

Demographic characteristics

The performance of diabetes self-care behaviors likely varies by demographic factors such as age, gender, ethnicity, employment status, religion, educational status, and income level. Studies from the US have documented ethnic difference in the performance of specific diabetes self-care behaviors among adults with T2D (Johnson, Ghildayal, Rockwood, & Everson-Rose, 2014; Vaccaro, Exebio, Zarini, & Huffman, 2014). One study for example, indicated blood glucose monitoring was higher in Alaska Natives. In addition, foot inspections were more commonly performed by Blacks and smoking cessation for Hispanics compared to non-Hispanic Whites (Johnson et al., 2014). Similarly, another study indicated that the performance of recommended diabetes self-care is likely higher among Black-Caribbean immigrants compared to Canadian-born people (Hyman et al., 2014). Some studies indicate that adult males with T2D have higher diabetes self-care behaviors compared to women (Bai, Chiou, & Chang, 2009; Choi, Kim, & Chang, 2015) though this may not be true for all specific self-care behaviors. Women, compared to men, are more likely to follow the recommended dietary self-care behaviors (Agborsangaya et al., 2013; Mathew, Gucciard, Melo, & Barata, 2012; Watkins, Quinn, Ruggiero, Quinn, & cHOI, 2013) while men likely do better with exercise self-care (Chourdakis, Kontogiannis, Malachas, Pliakas, & Kritis, 2014). Higher educational level, household income, and older age are also associated with better diabetes self-care behaviors (Chourdakis et al., 2014; Gurmu, Gela, & Aga, 2018; Y. Xu, Pan, & Liu, 2010).

Psychosocial factors

Diabetes self-efficacy

Diabetes self-care behaviors in adults with T2D are likely dependent on various psychosocial factors. Studies indicate that having higher self-efficacy is associated with greater diabetes self-care behaviors (Abubakari, Cousins, Thomas, Sharma, & Naderali, 2016; Gurmu et al., 2018; E.-H. Lee, Lee, & Moon, 2016; Walker, Gebregziabher, Martin-Harris, & Egede, 2014). For example, in one study diabetes self-efficacy explained 31.3% of the variance in the intention to perform self-care and 11.4% of variance in self-care behaviors among Iranian women with T2D (Didarloo et al., 2012). Correlates of self-efficacy are important to consider because there are inconsistencies in the literature concerning gender differences in diabetes self-efficacy for performing self-care activities. One study reported that men have greater self-efficacy compared to women (Burner, Menchine, Taylor, & Arora, 2013) whereas another showed the reverse (Choi et al., 2015). Studies consistently show that higher educational level (Cosansu & Erdogan, 2014; S. K. A. Sharoni & Wu, 2012), absence of comorbid conditions and diabetes complications (S. K. A. Sharoni & Wu, 2012) lead to better diabetes self-efficacy. In addition, longer duration of T2D, regular clinic visits, tobacco avoidance (S.-F. V. Wu et al., 2013), receiving diabetes education (Bohanny et al., 2013; S.-F. V. Wu et al., 2013), social support, and perceived interference with routine daily living, work, social and leisure activities (Cosansu & Erdogan, 2014) were positively associated with diabetes self-efficacy in people with T2D.

Diabetes knowledge

Diabetes knowledge is also another factor that potentially influences diabetes self-care behaviors in people with T2D. Studies show that patients with adequate diabetes knowledge tend to have better diabetes self-care (Ghannadi et al., 2016; Kassahun, Gesesew, Mwanri, & Eshetie, 2016; Kueh, Morris, Borkoles, & Shee, 2015; Saleh, Mumu, Ara, Begum, & Ali, 2012; Waheedi, Awad, Hatoum, & Enlund, 2017). While knowledge alone is not considered adequate for self-care without the other antecedent factors such as self-efficacy and motivation, it is an essential component (Ku & Kegels, 2015; Kueh et al., 2015). Higher educational level, longer duration of T2D (Islam et al., 2015; Kassahun et al., 2016), male gender, higher income, being married, and family history of diabetes (Islam et al., 2015)are positively related with better diabetes knowledge. Access to, and the type of sources of health information may also influence the level of diabetes knowledge(Alam, Speed, & Beaver, 2012; Zhao, 2014). Receiving health information from health professionals, family and friends, newspapers and magazines and the internet tend to be positively related to diabetes knowledge. Obtaining this information from churches and community organizations tend to be negatively related to diabetes knowledge (Zhao, 2014). Use of these health information sources likely vary based on factors such as language and literacy level, social network, cultural beliefs, religion and social responsibility (Alam et al., 2012).

Depression

Depression is one of the highly prevalent comorbid conditions in people with T2D (Al-Amer, Ramjan, Glew, Randall, & Salamonson, 2016; Habtewold, Alemu, & Haile, 2016; Mahalli, 2015; Sumlin et al., 2014). The risk of developing depression is 1.29 times higher in T2D patients compared to those without diabetes(A. Pan et al., 2010). DM patients with depression experience 1.5 times increased risk of all-cause mortality and 1.4 higher risk of CVD mortality (Dooren et al., 2013). Likewise depression is prevalent in persons with heart failure as well and associated with increased risk of morbidity and mortality and future CVD events (Adelborg et al., 2016; Newhouse & Jiang, 2014). Depression is associated with lower participation in diabetes self-care activities (Ahola & Groop, 2013; Maneze, Everett, Astorga, Yogendran, & Salamonson, 2016; Sumlin et al., 2014; Walker et al., 2014). However, studies show that self-efficacy (Al-Amer et al., 2016) and social support (Kim et al., 2015) likely mediate the relationship between depression and diabetes self-care behaviors. Studies also show that age and duration of DM (Almeida et al., 2016), diabetes-related complications (Habtewold et al., 2016), presence of DM-related comorbidities and physical inactivity (Salinero-Fort et al., 2018), lower education level (Majdan, Krajcovicova, Pekarcikova, Chereches, & O'Mullane, 2012), low family income and poor perceived social support (Habtewold et al., 2016), having no current job (Sweileh, Abu-Hadeed, Al-Jabi, & Zyoud, 2014), high perceived severity of illness (Majdan et al., 2012) likely predict depression in people with T2D.

Social support

Social support influences diabetes self-care behaviors. Many studies show that higher social support positively correlates with greater diabetes self-care behaviors in people with T2D (Rosland et al., 2014; Smalls, Gregory, Zoller, & Egede, 2014, 2015a, 2015b; Vaccaro et al., 2014; Vissenberg et al., 2016; Watkins et al., 2013). In particular, studies show that social support significantly correlates with better diet control and physical activity while health care support decreases fat consumption (Khymdeit, Rao, Narayanan, & Mayya, 2016). Another study also showed that social support is a strong predictor for the diabetes self-care behaviors of general diet, specific diet, and foot care (Watkins et al., 2013). The literature also indicates that unmet needs for social support explain about 30% of the variance in diabetes self-care behaviors (Y. Song et al., 2012). In contrast, Sharoni et al. (2015) found a significant negative correlation between social support and diabetes self-care behaviors suggesting that as social support increases diabetes self-care behaviors decrease. For example, one of the studies included83 middle-aged Korean American adults with uncontrolled T2D (Y. Song et al., 2012) while the other study utilized200 elderly DM patients in Malaysia (S. A. Sharoni et al., 2015). Song et al. (2012) used the social support subscale of the Diabetes Care Profile whereas Sharoni et al. (2015) used the medical outcomes study (MOS) social support questionnaire These differences in populations and instruments to measure social support likely contributed to the differences reported.

Socio-environmental factors including family characteristics, health provider-patient communication, and neighborhood characteristics can influences social support for diabetes self-care. Better provider-patient communication likely correlates with improved diabetes self-care (J. Gao et al., 2013). Studies show that built neighborhood factors including food insecurity, social cohesion, neighborhood violence and aesthetics, and walking environment are associated with specific diabetes self-care behaviors (Smalls et al., 2014, 2015a, 2015b). Neighborhood factors can also influence diabetes self-efficacy and social support for diabetes self-care (Juarez-Ramirez et al., 2015; Vijayaraghavan, Jacobs, Seligman, & Fernandez, 2011).

Families and friends are the most common social support providers for diabetes self-care (Gunn, Seers, Posner, & Coates, 2012; Juarez-Ramirez et al., 2015). The diabetes-specific family support involves behaviors such as reminding patient to take medication and monitor blood glucose on time, planning healthy meals, and encouraging engagement in physical activity and consultation with a healthcare provider. Family support improves the patient's self-efficacy, perceived social support, diabetes self-care behaviors, and diabetes knowledge (Baig, Benitez, Quinn, & Burnet, 2015; Vaccaro et al., 2014). However, families may play either supportive or nonsupportive role in DM management (Mayberry & Osborn, 2012, 2014; Rosland, Heisler, Choi, Silveira, & Piette, 2010). The supportive family behavior helps to improve diabetes self-care performance while the nonsupportive one is associated with less adherence to the recommended self-care behaviors (Mayberry & Osborn, 2014). Studies show that women (Mansyur, Rustved, Nash, & Jibaja-Weiss, 2015; Rosland et al., 2010), those who live alone (Gunn et al., 2012; Mayberry & Osborn, 2012, 2014), and older people, those with some education and depression symptoms (Rosland et al., 2010) experience nonsupportive family behaviors in diabetes self-care. There are cultural and socioeconomic variations in the family supportive and nonsupportive behaviors, the degree of family involvement, and the type of family involved in diabetes self-care (Baig et al., 2015; Belue et al., 2013; Cha, Yang, et al., 2012; Peyrot et al., 2015; Ramal, Petersen, Ingram, & Champlin, 2012). These include ethnicity, cultural food preferences, family traditions, access to diabetic diet, the influence of DM patient's dietary change on the family, and the involvement of extended family members in support for diabetes self-care in some cultures.

Clinical factors

Comorbidities

A number of clinical variables influence engagement in diabetes self-care behaviors. Studies show that the existence of comorbid conditions as well as their treatment negatively influences the performance of diabetes self-care (Ahola & Groop, 2013; Dixon et al., 2014; Denise Soltow Hershey, Given, Given, Corser, & Eye, 2014; Denise Solto Hershey, Tipton, Given, & Davis, 2012; Trief et al., 2013). For example, DM patients with comorbid conditions such as CVD and depression tend to suffer from emotional disturbances that may result in loss of interest and confusion that interfere with engaging in self-care behaviors of diet, physical activity, and medication taking (Ahola & Groop, 2013; Dixon et al., 2014). The use of chemotherapy for cancer and its related symptoms (Denise Soltow Hershey et al., 2014; Denise Solto Hershey et al., 2012) and moderate-to-severe symptoms of depression (Dixon et al., 2014) predict lower diabetes self-care behaviors in people with T2D. Studies also report that comorbidities such as nephropathy and neuropathy (Mehravar et al., 2016) and cognitive decline and dementia (Cuevas & Stuifbegen, 2017; Ojo & Brooke, 2015; Tomlin & Snclair, 2016) are associated with poorer diabetes self-care behaviors. Patients with a greater number of comorbidities and those with discordant comorbidities likely experience worse diabetes self-care (Magnan, Palta, Johnson, et al., 2015; Trief et al., 2013). As the most distressful comorbid condition, HF can also distract from self-care and confound the person's assessment and management of T2D related symptoms (Dunbar et al., 2014).

Body mass index

Body mass index (BMI) is associated with performance of self-care in patients with chronic illnesses including T2D (Bos-Touwen et al., 2015; Chourdakis et al., 2014). A study shows that T2D patients with a BMI ≥ 35 Kg/m^2 are less likely to engage in healthy dietary and physical activity self-care behaviors and perceive them as more burdensome compared to those with BMI < 35 Kg/m^2 (Dixon et al., 2014). A randomized clinical trial supported that T2D patients who experience a pattern of continued weight loss are 2.2 (95% CI = 1.49 – 3.37) times more likely perform diabetes self-care (Traina, Slee, Woo, & Canovatchel, 2015).

Heart failure severity

There is paucity of research literature describing the influence of HF severity on diabetes self-care behaviors. However, high symptom frequency, symptom-related interference with enjoyment of life, depressive symptoms, cognitive impairment and NYHA class IV negatively influence HF self-care (Graven, Grant, & Gordon, 2015) may also affect diabetes self-care behaviors in people with T2D and comorbid HF.

Number of medications

There is little evidence that provides information on the association between number of DM medication and diabetes self-care behaviors. Studies have reported however, that DM treatment category of ≥ 2 diabetic tablets versus one diabetic tablet (Abubakari et al., 2016), belief in treatment effectiveness (Gunggu, Thon, & Lian, 2016) and using insulin as a treatment (Y. Xu et al., 2010) are associated with better diabetes self-care behaviors in people with T2D.More complex diabetes treatment routines are said to explain 9% of the variance in adherence to physical activity, 21% of the variance in blood glucose monitoring, and 7% of the variance in overall self-care behaviors (Abubakari et al., 2016). A T2D patient's belief in treatment effectiveness significantly predicts increased diabetes self-care behaviors (Gunggu et al., 2016). A study also shows that patients who use insulin as a treatment are 15.39 (95% CI = 1.56 – 151.56) times more likely take medications as prescribed(Y. Xu et al., 2010).

There is also paucity of literature describing the relationship between number of daily HF medication and diabetes self-care behaviors. A high number of daily HF medications which is typical may negatively influence self-efficacy for diabetes self-care behaviors as it does for self-efficacy for HF self-care (Ausili et al., 2016).

Duration with diabetes

Duration of time living with T2D since diagnosis may influence the likelihood of engaging in diabetes self-care. Studies show that longer duration of T2D correlates with higher overall diabetes self-care behaviors (Bai et al., 2009; Trief et al., 2013). In addition, it correlates with specific self-care behaviors such as physical activity (Chourdakis et al., 2014; Ko et al., 2012), blood glucose self-monitoring (Abubakari et al., 2016; Y. Xu et al., 2010), and eating a healthy diet (Ko et al., 2012).

Glycemic control

Diabetes self-care behaviors are essential for the improvement of glycemic control in the DM population. The reduction of HbA1c below 7%, which is equivalent to a mean FBG of 142 mg/dL , has been recommended for the prevention of cardiovascular complications in nonpregnant adults(ADA, 2019c). Studies show that optimal diabetes self-care behaviors in adults with T2D patients likely relate to reduced HbA1c levels (Khanna et al., 2012; Ouyang et al., 2015; Park et al., 2015; Ricci-Cabello et al., 2014; Tang et al., 2014; Tshiananga et al., 2012). A randomized controlled trial demonstrated that a diabetes self-care intervention significantly improved FBG level in addition to HbA1c and postprandial 2-hour blood glucose (Zheng, Liu, Liu, & Deng, 2019). A meta-analysis of randomized controlled trials indicates that a mean change of -0.70% HbA1c for a nurse-led diabetes self-care education group compared to the usual care group with an effect size of 0.506 (Tshiananga et al., 2012). Another meta-analysis of 20 randomized controlled trials also shows that diabetes self-care education programs yield -0.31% reduction of HbA1c (Ricci-Cabello et al., 2014). However, a recent Cochrane review indicates self-management interventions for T2D with severe mental illness had no significant effect on HgA1c (McBain et al., 2016).

Study Aims

The purpose of this study was to provide a deeper conceptual understanding of the correlates of diabetes self-care behaviors in adults with T2D and comorbid HF. Sociodemographic and clinical correlates of diabetes self-efficacy in adults with T2D and comorbid HF was described in Aim 1. Good self-rated health and presence of implantable cardioverter defibrillator (ICD) had a significant positive correlation with diabetes self-efficacy while taking both oral antiglycemic medication and insulin, history of depression, cardiac pacemaker, and digitalis were negatively related. Demographic, clinical and psychosocial factors correlation with diabetes self-care behaviors (foot care, exercise, and self-monitoring blood glucose) was examined in Aim 2. This analysis provided factors that merit targeting in future diabetes self-care interventions in people with T2D and comorbid HF. These factors include the presence of 2 or more comorbidities, a high school or lower educational level, non-African American (white) ethnicity, and the use of aldosterone inhibitor. The relationship between diabetes self-care behaviors and glycemic control (HbA1c and FBG) was analyzed while adjusting for demographic, clinical, and psychosocial variables in Aim 3. The analysis revealed that none of the dimensions of diabetes self-care behaviors predicted either HbA1c or FBG despite the SDSCA general diet, the SDSCA specific diet, and the SDSCA exercise dimensions were associated with HbA1c in the bivariate statistics. Other factors including DM-related end organ failure, taking insulin only, taking oral antiglycemic agents and insulin, African American race, and dyslipidemia emerged as significant predictors of HbA1c. Years since diagnosis of HF, taking insulin, DM-related end organ failure, and total daily medication also emerged as significant predictors of FBG.

RESEARCH METHODS

Study Design

This dissertation is based on a secondary analysis of a baseline data from a randomized study that tested a 6-month integrated self-care intervention for adult persons with comorbid HF and T2D using a cross-sectional, correlational design. Three papers that characterize each dissertation aim was developed to provide greater knowledge and insight of the correlates of diabetes self-care behaviors in adults with T2D and comorbid HF.

Study Participants and Setting

The original randomized controlled trial enrolled adult patients with comorbid HF and T2D during hospitalization or within 3 months of discharge for worsening HF. Participants' enrollment took place at 1 of 4 large urban-tertiary hospitals in Atlanta, Georgia during 2010 – 2013. Participants who were hospitalized for HF within the past 3 months, 21-80 years old, had New York Heart Association (NYHA) functional classification II-IV, had comorbid T2D, were ambulatory and eligible for physical activity, had English fluency, taking optimal HF medications according to guidelines, and who were eligible for low sodium and carbohydrate diet were included in the study. The exclusion criteria were new diagnosis or first HF admission; depressive symptoms score of 10 or above on the Patient Health Questionnaire-9 (PHQ-9);

cognitive impairment score of 11 or above on the Blessed Cognitive Screening Tool (BCST); uncorrected hearing or vision problem; undergoing evaluation for cardiac transplant or evaluation for ventricular assist device; renal failure; lack of telephone access; and severe chronic pulmonary disease and earlier stroke impeding ambulation.

The sample size was calculated using Green's recommendation for the determination of sample size for multiple regression analysis (Green, 1991). Baseline data of 180 participants were included in this study. The effect size (f^2) for this sample size is 0.044, which is small to medium and satisfied the requirement for a power of 0.80 based on Cohen's recommendation at statistical significance level of 0.05 (Cohen, 1988).

Data Collection

Different data collection strategies were used in this study. Study-developed data extraction forms and a battery of standardized instruments were used to collect demographic, clinical, and psychosocial data from medical records and self-report. The summary of variables and measurement instruments are provided in Table 1.

Table 1-0-1 Summary of variables and measurement instrument

Variable	Instrument	Instrument Description	Psychometrics
Demographic information	Demographic data sheet	Extracted age, sex, race, marital status, education, and living arrangement from medical records	Study-developed form.
Psychosocial variables: Diabetes self-efficacy	Perceived Diabetes Self-Management Scale (PDSMS)	8-item scale elicits patient's confidence for self-care	Alpha coefficient reported at 0.83 (Wallston, Rothman, & Cherrington, 2007)
Diabetes knowledge	General segment of Michigan Diabetes Knowledge Test (DMKT)	14-item test appropriate for adults with T1D and T2D	Alpha coefficient reported at 0.71 (Fitzgerald et al., 2016)
Depression	Patient Health Questionnaire-9 (PHQ-9)	9-item scale used to assess depressive symptoms	Alpha of 0.89 and sensitivity and specificity of 88% reported (Kroenke, Spitzer, & Williams, 2001)
Social support	ENRICHD Social Support Instrument (ESSI)	7-item elicits perceived social support	Alpha coefficient reported at 0.86 (ENRICHD, 2000)
Clinical variables: Body mass index (BMI),	Clinical data extraction sheet	Extracted BMI values from medical records	Study-developed form
Perceived health rating	Self-report instrument	A single self-report survey with responses as 'Poor', 'Fair', 'Good', or 'Excellent'.	Study-developed item
New York Heart Association (NYHA)	Clinical data extraction sheet	Extracted NYHA values from medical records	Study-developed form
Left ventricular ejection fraction (LVEF)	Clinical data extraction sheet	Extracted LVEF values from medical records	Study-developed form
T2D duration	Clinical data extraction sheet	Extracted duration of T2D since first diagnosis	Study-developed form
HF duration	Clinical data extraction sheet	Extracted duration of HF since first diagnosis	Study-developed form
End organ failure	Clinical data extraction sheet	Extracted DM-related end organ failure from medical records (Yes/No)	Study-developed form
Charlson comorbidity index	The Charlson Comorbidity Index (CCI)	A weighted index score of the total of person's comorbid conditions, extracted from medical records and self report	Used in multiple studies with well-established validity (Charlson, Szatrowski, Peterson, & Gold, 1994)
Charlson comorbidity number > 2	The Charlson Comorbidity indicator > 2	A simple count of the number of comorbidities (Yes/No) to capture persons with other comorbidities besides T2D and HF	Study-adapted CCI
Other comorbidities	Comorbidity data extraction sheet	Extracted comorbid conditions that are not part of CCI from medical records	Study-developed form
DM management regimen	Clinical data extraction sheet	Extracted T2D management regimen as diet alone or diet plus medication from medical records	Study-developed form
Oral DM medication used	Clinical data extraction sheet	Extracted oral antiglycemic medication uses as Yes/No from medical records	Study-developed form
Insulin use	Clinical data extraction sheet	Extracted insulin use as Yes/No from medical records	Study-developed form

Table continued on next page >>>

DM medication category	Clinical data extraction sheet	Extracted the 4 categories of T2D medications (oral medication only, insulin only, both oral and insulin, or no to both) from medical category	Study-developed form
Angiotensin-converting enzyme (ACE) inhibitors use	Clinical data extraction sheet	Extracted ACE use as Yes/No from medical records	Study-developed form
Angiotensin receptor blockers (ARB) use	Clinical data extraction sheet	Extracted ARB use as Yes/No from medical records	Study-developed form
Digitalis use	Clinical data extraction sheet	Extracted digitalis use as Yes/No from medical records	Study-developed form
Aldosterone inhibitors use	Clinical data extraction sheet	Extracted the use of aldosterone inhibitors as Yes/No from medical records	Study-developed form
Diuretics use	Clinical data extraction sheet	Extracted diuretics use as Yes/No from medical records	Study-developed form
Loop diuretics use	Clinical data extraction sheet	Extracted loop diuretics use as Yes/No from medical records	Study-developed form
Diabetes self-care behaviors	The Summary of Diabetes Self-Care Activities (SDSCA)	2-item each for foot care, exercise, and blood glucose testing self-reporting of how many days performed these behaviors in the previous week	Alpha of 0.83 for exercise, 0.77 for foot care, and 0.92 for blood glucose testing reported (Aljohani, Kendall, & Sinder, 2016)
Glycemic control biomarkers: Glycated hemoglobin (HbA1c)	High performance liquid chromatography with	Test performed in the clinical laboratory of Emory Hospital system using whole blood	Test standardized through commercially available controls (CV <2%)
Fasting blood glucose (FBG)	Glucometeter	Test was performed after 8 hours of fasting	

Data Analysis

The baseline data generated from medical records and through self-report were analyzed using IBM SPSS for Windows version 24. All data were examined for accuracy, completeness, outliers, and missing values before analysis.

Aim 1: *Characterize the sociodemographic and clinical correlates of self-care behaviors in adults with T2D and comorbid HF.*

The variable, PDSMS score, distribution was assessed by visual inspection and the Shapro-Wilk and Kolmogorov-Smirnov tests. The data were normally distributed. The general characteristics of the participants were computed using descriptive statistics. Bivariate statistics including Pearson's correlation, an independent-sample t-test, and one-way analysis of variance (ANOVA) were computed for determining sociodemographic and clinical variables relationship with diabetes self-efficacy. Statistical significance was set at 5% and the associated 95% confidence intervals (95%CI) were reported. Stepwise multiple linear regression models were used to explore sociodemographic and clinical factors predicting diabetes self-efficacy (PDSMS). Both continuous and categorical predictor variables were included in the regression models. Multi-categorical independent variables were dummy coded before entering into the models. To avoid issues associated with multicollinearity, checks were completed to see if (a) the condition index was <30, (b) that the variance inflation factors (VIF) were < 5, and (c) tolerance was > 0.2. Moreover, the Durbin-Watson test was used to assess the independence of residuals (value of 2 for complete independence).

Aim 2: ***Describe the correlates of diabetes self-care behaviors in adults with T2D and comorbid HF.***

Bivariate analysis using Biseral correlation and Chi-square test of independence were performed to determine the demographic, clinical and psychosocial variables relationships with diabetes self-care behaviors. Forward stepwise logistic regression along with likelihood ratios was used to explore the predictors of diabetes self-care behaviors of exercise, blood glucose testing, and foot care. A 95% confidence interval and p-value < 0.05 were used to determine statistical significance. The Cox and Snell R square and Nagelkerke square values were used to estimate variance explained in the outcomes variables. Adapting Wald's Chi-square test for the regression parameter estimation, an odds ratio (eB) was applied to test and evaluate the fit of each condition in the model. An odds ratio (OD) < 1 was defined as predictor(s) of less performance and OR > 1 as high performance of exercise, blood glucose testing, and foot care.

Aim 3: ***Determine the relationship between diabetes self-care behaviors and glycemic control in adults with T2D and comorbid HF.***

The distributions of outcome variables (HbA1c and FBG) were scrutinized for normality by visual inspection and the Shapro-Wilk and Kolmogorov-Smirnov tests. The normality assessment revealed skewness in the distribution of these outcome data. This problem was resolved using square root and base 10 log transformation methods. The HbA1c data that had moderately positive skewness was square root transformed while the FBG data that had substantial positive skewness was base 10 log transformed (Tabachnick & Fidell, 2007). Bivariate analysis using correlation coefficients (Pearson *r* and Spearman's *rho*), independent-sample t-test, and one-way analysis of variance (ANOVA) were conducted to assess the demographic, clinical, psychosocial variables, and diabetes self-care behaviors relationships with HbA1c and FBG. Pearson *r* was used when the two variables in the correlation analysis were normally distributed and Spearman's *rho* was used when the assumption of normality violated by at least one variable in the analysis and when this problem could not be fixed using data transformation methods. Statistical significance was set at 5%. Hierarchical multiple regressions were used to assess whether greater diabetes self-care behaviors were associated with better glycemic control (lower glycated hemoglobin [HbA1c] and fasting blood glucose [FBG]) after controlling for demographic, clinical and psychosocial variables. Multi-categorical independent variables were dummy coded before entering into the models. To avoid the issues of multicollinearity, inter-correlations between variables were examined but no inter-correlation higher than 0.80 was found. Moreover, the Durbin-Watson test was used to assess the independence of residuals (value of 2 for complete independence). Magnitude of difference and effect sizes were also computed for each variable.

Ethical Consideration

The study was approved by the Institutional Review Board (IRB) of Emory University and all participating institutions, and all participants provided written informed consent. The Research and Development Committee (RDC) of the Department of Veterans Affairs granted approval for the current study. In addition, the IRB of the College of Health Sciences at Addis Ababa University approved this research project.

Strength and Limitations of the Study

Comorbid chronic illnesses are prevalent and increase disease burden and cost of care in people with T2D (Lin, Kent, Winn, Cohen, & Neumann, 2015). Research studies that addresses these comorbidities would lead to into more effective interventions (Dunbar et al., 2014; Smith, Soubhi, Fortin, Hudon, & O'Dowd, 2012). Most studies investigating diabetes self-care behaviors in T2D however, have not considered comorbid conditions (Ouyang et al., 2015; Park et al., 2015; Tshiananga et al., 2012; Zheng et al., 2019). As a consequence, how patients' engage in self-care behaviors in the presence of other comorbid illnesses is largely unknown. Exploring for the first time the correlates of diabetes self-care behaviors in adults with T2D and comorbid HF is a major strength of this study. In addition, the largely male and African American study sample was strength since less is known about this T2D subgroup and their self-care practices. An important concern when exploring the association between predictors and outcome variables is confounding. In this study, an attempt was made to control for the covariates and reduce the threat to bias using stepwise logistics and linear regression models. A cross-sectional design does not allow identifying the temporal dimension of the variables or infer causality. In addition, whether findings from this study can be generalized to other populations such as women with T2D and comorbid HF or Caucasians is unknown.

The medication adherence dimension was not measured in the baseline data despite an instrument (SDSCA) with established validity and reliability was used to measure diabetes self-care behaviors. In addition, the social support (ESSI) had high missing values (n = 62) that limited its sample size for the analysis in this study though not treated as an outcome variable.

Summary

Both T2D and HF are increasing in prevalence worldwide and is anticipated to rise exponentially over the next several decades. Because these chronic conditions often coexist and require complex treatment regimens to optimize health outcomes, it is increasingly important to understand how self-care behaviors may be influenced. This is the first study to our knowledge to examine how diabetes self-care behaviors are influenced by sociodemographic, clinical and psychosocial factors among individuals with T2D and HF. Findings from this study maybe used to inform effective self-care interventions to improve patient outcomes, avoid adverse events and enhance quality of life in this population.

CHAPTER II

Article 1: Sociodemographic and Clinical Correlates of Diabetes Self-Efficacy in Adults with Type 2 Diabetes and Comorbid Heart Failure

Authors:

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Abstract

Background: Heart failure (HF) is a comorbidity that complicates type 2 diabetes mellitus (T2D) management and increases the chance of death. However, little is known concerning factors related with diabetes self-efficacy in comorbid HF.

Purpose: This study was aimed at describing sociodemographic and clinical correlates of diabetes self-efficacy in adults with T2D and comorbid HF.

Methods: A correlational design was used to analyze cross-sectional baseline data from a randomized study that tested a 6-month integrated self-care intervention targeting adults with concomitant HF and T2D. Data from 180 participants' at baseline were included in this study. Data were collected from medical records and self-report. Stepwise multiple linear regression analysis was used to examine socioeconomic and clinical variables related with diabetes self-efficacy.

Result: The participants mean age was 58.1±10.7 years and the majority were male (n = 118, 65.6%) and African American (n = 119, 66.1%). Good self-rated health and presence of an implantable cardioverter defibrillator (ICD) had a significant positive correlation with diabetes self-efficacy while taking both oral antiglycemic medication and insulin, history of depression, cardiac pacemaker, and digitalis were negatively related. These variables collectively explained 22.4% of variations in diabetes self-efficacy.

Conclusion: Our study suggested that using self-rated health would provide a comprehensive patient-centered assessment to evaluate their health status. Further studies are also warranted to ascertain the pathways linking ICD, pacemaker, and digitalis treatment with diabetes self-efficacy.

Keywords: type 2 diabetes, diabetes self-efficacy; heart failure; comorbidity, nursing

Introduction

Type 2 diabetes mellitus (T2D) is now an epidemic of significant global and national health concern. The report from the International Diabetes Federation (IDF) shows that about 425 million adult people aged 20-79 years were living with diabetes mellitus all over the world in 2017 and this figure would reach 629 million by 2045 (IDF, 2017). More than 90% of all diabetes cases have T2D. Regardless of the regional variation, the trend shows sustained increase in diabetes prevalence all over the world (NCD-RisC, 2016). People with T2D often develop comorbid conditions such as hypertension, obesity, hyperlipidemia, chronic kidney disease, and cardiovascular disease (Iglay et al., 2016). One of the cardiovascular comorbidities that complicate diabetes management and increases the chance of dying in T2D is HF. Globally, HF is prevalent in 14.9% people with T2D (Einarson et al., 2018) whereas the prevalence in the general population is 1-12%(Roger, 2013). The incidence of HF is 1.69 (95%CI: 1.50, 1.90) times higher in people having T2D and 2.68 (95%CI: 1.76, 4.09) in those with type 1 diabetes compared to those without diabetes (Larsson et al., 2018). People with comorbid T2D and HF have significantly higher odds of hospitalization and mortality than those with either disease alone (Lehrke & Marx, 2017). Sudden cardiac death in particular has a higher incidence (5.9%) in T2D compared to those without diabetes (1.7%), is a great concern when there is comorbid heart failure(Junttila et al., 2010). But, these adverse health outcomes can be prevented or delayed through better diabetes self-care behaviors including eating healthful diet, regular physical exercise, performing foot check, and monitoring blood glucose (Sirikamonsathian, Sriratanaban, Hiransuthikul, & Lertmaharit, 2013; Wichit, Mnatzaganian, Courtney, Schulz, & Johnson, 2017). An essential precursor for any of these behaviors is self-efficacy, or the confidence an individual has in carrying out diabetes self-care. Little knowledge exists concerning factors influencing diabetes self-efficacy in the context of comorbid heart failure.

Background

Self-efficacy, the construct which was first introduced within Bandura's social cognitive theory, denotes an individual's beliefs in own ability to plan and carry out a course of action in order to achieve a designated goal (Bandura, 1997). Self-efficacy belief is considered as an important determinant of human motivation, affect, and action. It can impinge on the health behavior of people. Self-efficacy is linked with specific circumstances and activities and concerned with personal judgment of what one can do with skills already attained (Bijl & Shortridge-Baggett, 2002). Self-efficacy theory has two important components: efficacy expectations and outcome expectations (Bandura, 1997). The efficacy expectation refers to the confidence and determination of a person to practice specific behavior while outcome expectation concerns an individual's acceptance of the outcome that results from practicing the desired behavior.

Studies have consistently indicated that possessing higher perceived self-efficacy is related to greater diabetes self-care behaviors (Abubakari et al., 2016; Devarajoon & Chinna, 2017; E.-H. Lee et al., 2016). According to these studies, perceived self-efficacy is a significant predictor and antecedent of diabetes self-care behaviors. Examples are found in studies indicating that self-efficacy had a significant and direct effect on diabetes self-care behaviors (Devarajoon & Chinna, 2017). Another study has also reported that mediated by self-care behaviors, self-efficacy indirectly influence glycated hemoglobin (HbA1c) level (J. Gao et al., 2013).Two experimental studies have also reported that self-efficacy enhancing education programs resulted in significant improvement of foot self-care behavior, foot self-efficacy, foot care outcome expectation, knowledge of foot care, quality of life, fasting blood glucose, and foot hygiene in older adults with diabetes (S. K. A. Sharoni, Rahman, Minhat, Ghazali, & Ong, 2017; S. K. A. Sharoni, Rahman, Minhat, Shariff-Ghazali, & Ong, 2018).

Correlates of self-efficacy are important to consider, however, there is inconsistency in the body of literature concerning gender difference in self-efficacy for diabetes self-care. One study reported that men had increased self-efficacy compared to women (Burner et al., 2013), whereas another study showed the reverse (Choi et al., 2015). However, studies have consistently reported that attainment of higher educational level and longer years lived with T2D (Cosansu & Erdogan, 2014; S. K. A. Sharoni & Wu, 2012), absence of comorbid chronic illness and diabetes complications (S. K. A. Sharoni & Wu, 2012), regular visits to healthcare institution and not smoking (S.-F. V. Wu et al., 2013), receiving diabetes education, health literacy and being employed (Bohanny et al., 2013), and social support, outcome expectancy and perceived interference with daily living, work, social and leisure activities (Cosansu & Erdogan, 2014)are positively associated with higher self-efficacy for diabetes self-care. Bohanny and colleagues (2013) specifically showed that health literacy, taking part in diabetes education program, and being employed collectively explained 11.8% of the variance in diabetes self-efficacy.

The current study adapted an integrated conceptual model for guiding self-care research in HF patients(Dunbar et al., 2008). The model integrates ideas from theories of self-management and adult learning used in patient education. The original model considered self-efficacy, parallel to sociodemographic and clinical variables, as an antecedent of self-care behaviors. In this study, however, we were interested to investigate if sociodemographic and clinical variables also serve as antecedents of diabetes self-efficacy in the context of comorbid heart failure (HF). As described above, studies have identified some antecedents of diabetes self-efficacy. Most of these studies, however, did not take into account the existence of comorbid chronic illness as a context that can influence diabetes self-efficacy. Only one pilot study has tested an intervention based on an integrated self-care model in people with comorbid HF and T2D. Age and left ventricular ejection fraction (LVEF) were reported as significant covariates of diabetes self-efficacy (Dunbar et al., 2014). Little evidence exists concerning the antecedents of diabetes self-efficacy for T2D patients who also have other comorbid chronic illnesses. These data are important for designing self-care intervention studies for persons with T2D and comorbid HF. The purpose of this study was to describe sociodemographic and clinical correlates of diabetes self-efficacy in T2D adults with comorbid HF. Our hypothesis was that sociodemographic (age, sex, race, education, marital status, and living arrangement) and clinical (perceived health status, comorbidity index and comorbid conditions, body mass index [BMI], heart failure severity, medications, HF duration, and diabetes duration) variables are associated with diabetes self-efficacy.

Methods

Study design

A correlational design was used to analyze a cross-sectional baseline data from a randomized clinical trial that tested a 6-month intervention based on an integrated self-care model for adults with concomitant HF and T2D who were receiving care in an outpatient Heart Failure Center located in the southeast. The original study aim was improvement of HF- and T2D-specific outcomes. The present study explored sociodemographic and clinical predictors of diabetes self-efficacy at baseline, prior to intervention.

Participants and data collection

The original randomized controlled trial enrolled adult patients with comorbid HF and T2D at the time of hospitalization or in the 3 months period of discharge for worsening HF. Inclusion criteria for the parent study included: (a) participants who were hospitalized for HF in the previous three months period, (b) 21 to 80 years, (c) had New York Heart Association (NYHA) functional classification II-IV, (d) had comorbid T2D, (e) were able to move and fit to exercise, (f) had English fluency, (g) were optimally taking HF medication, and (h) who were qualified for eating diet with low sodium and carbohydrate were included in the study. The exclusion criteria were: (a) new diagnosis or first HF admission; (b) cognitive impairment score ≥ 11 measured using the Blessed Cognitive Screening Tool (BCST); (c) untreated problem of the ear or eyesight; (d) going through assessment for heart-related transplant; (e) lack of access to phone; and (f) serious prolonged lung disease and previous stroke impeding ambulation. The Institutional Review Boards (IRB) of all participating institutions approved the study and each participant provided written informed consent.

The sample size was computed using Green's recommendation for the determination of sample size for multiple regression analysis using a sample size of 180 (Green, 1991).The effect size for this sample size was 0.044, which is considered moderate and satisfied the requirement for a power of 0.80 based on Cohen's recommendation at statistical significance level of 0.05 (Cohen, 1988).

Measurement

Sociodemographic and clinical information

Medical records and patient self-report were sources for clinical and sociodemographic data. These data included age, sex, race/ethnicity, marital status, education, BMI, perceived health rating, living arrangement, NYHA functional classification, years since diagnosis of T2D and HF, LVEF, diabetes with end organ failure, diabetes management regimen/type, medications, and comorbid conditions.

Charlson comorbidity index

The Charlson comorbidity index (CCI) widely used in clinical research to manage the confounding influence of comorbidities, was used to document comorbid conditions (Charlson, Pompei, Ales, & MacKenzie, 1987; Charlson et al., 1994).

Diabetes self-efficacy

The 8-item Perceived Diabetes Self-Management Scale (PDSMS) was used to measure diabetes self-efficacy(Wallston et al., 2007). The scale includes responses for each item ranging from strongly disagree (=1) to strongly agree (=5) with the total scores ranging from 8 to 40. A higher score shows better self-confidence in performing diabetes self-care and the instrument has adequate reliability in the T2D population with Cronbach's alpha's ranging from 0.83 in the original study to 0.94 in a latter study (H. Lee, Ahn, & Kim, 2009).

Data analysis

All data were assessed for data entry accuracy, completeness, possible outliers, and missing values prior to analysis. The normality of the outcome variable, PDSMS score, was assessed by visual inspection and the Shapro-Wilk and Kolmogorov-Smirnov tests. The data were distributed normally. The general characteristics of the participants were computed using descriptive statistics. Bivariate statistics including Pearson's correlation, an independent-sample t-test, and one-way analysis of variance (ANOVA) were computed for determining sociodemographic and clinical variables relationships with diabetes self-efficacy. Statistical significance was set at 0.05 and the associated 95% confidence intervals (95%CI) were reported. Stepwise multiple linear regression models were used to explore sociodemographic and clinical factors predicting diabetes self-efficacy (PDSMS). Both continuous and categorical predictor variables were put into the regression models. Multi-categorical independent variables were dummy coded before entering into the models. To avoid issues associated with multicollinearity, we have checked to see if (a) the condition index was <30, (b) that the variance inflation factors (VIF) were < 5, and (c) tolerance was > 0.2. Moreover, the Durbin-Watson test was used to assess the independence of residuals (value of 2 for complete independence). The SPSS for Windows version 24 (IBM SPSS Statistics 24) was used for data management and analysis.

Results

Participant characteristics

The participants in this study had a mean age of 58.1±10.7years (Table 1), the majority were male (n= 118, 65.6%) and African American (n= 119, 66.1%). Most had more than high school education (n = 114, 63.3%) and were living with a spouse or children (n = 116, 64.4%).The average number of years since diagnosis forT2D was 11.1 ± 8.4 for HF 5.3 ±5.9 (Table 2). Clinically, the mean left ventricular ejection fraction was 33.6 ± 16.9, the average number of medications taken daily was 12.3±3.9 and most had an average of 4.2 ± 2.3 chronic conditions (Table 3).

Sociodemographic factors on diabetes self-efficacy

African American T2D-HF patients had significantly lower diabetes self-efficacy scores (M = 26.2±5.9) compared to their white counterparts (M = 28.4±6.3), t (169) = -2.278, p = 0.025 (Mean difference [*MD]* = -2.25, 95%CI: -4.20, -0.29) (Table 1). The one-way ANOVA revealed significant difference in diabetes self-efficacy scores for the three perceived health ratings, F (2, 165) = 4.383, p = 0.014 with large effect size (0.95) (Table 1). Post-hoc analysis using the Sidak method showed that the mean diabetes self-efficacy scores for those with a fair perceived health rating (*M* = 26.2±5.7) was significantly lower than those with a good perceived health rating (*MD* = -3.4, 95%CI: -6.185 to -0.630). There was no additional sociodemographic variables associated with diabetes self-efficacy.

Table 2-0-1 Demographic characteristics of comorbid T2D-HF patients on diabetes self-efficacy (N = 180)

Characteristics	Overall n (%)	Perceived Diabetes Self-Management Scale Score	
		Mean ±SD	Test of Association
Age, y, mean ±SD	58.1 (10.7)	27.7 (6.2)	$r = 0.003$, $p = 0.974$
Sex:			
Female	62 (34.4%)	28.5 (6.4)	t = 1.228, df = 169, $p = 0.222$
Male	118 (65.6%)	27.2 (6.1)	
Race:			
None-African American (white, Asian)	61 (33.9%)	28.4 (6.3)	t = -2.278, df = 169, $p = 0.025$
African American	119 (66.1%)	26.2 (5.9)	
Marital status:			
Single/divorced/widowed	90 (50.0%)	27.9 (6.4)	t = 0.506, df = 169, $p = 0.614$
Married/domestic partner	90 (50.0%)	27.4 (6.1)	
Education:			
High school/less	65 (36.1%)	28.1 (6.4)	t = 0.639, df = 168, $p = 0.524$
Tech/Vocational/College/Graduate school	114 (63.3%)	27.4 (6.2)	
BMI, kg/m^2, mean ±SD	36.7 (8.9)	27.7 (6.2)	$r = -0.086$, $p = 0.265$
Perceived health rating:			
Poor	53 (29.4%)	27.5 (6.5)	1-ANOVA = F (2, 165) = 4.383, p = 0.014
Fair	73 (40.6%)	26.2 (5.7)	***Sidak post hoc:*** Fair Vs Good = MD = -3.4, $p =$ 0.011
Good	49 (27.2%)	29.6 (6.2)	
Living arrangement:			
Live alone	41 (22.8%)	26.9 (6.3)	1-ANOVA = F(2, 168) = 0.333, $p = 0.717$
Live with spouse/children	116 (64.4%)	27.8 (5.9)	
Live with sibling/other relatives/friends	23 (12.8%)	28.1 (7.4)	

r = Pearson's correlation coefficient; t = independent-sample t-test; 1-ANOVA = One –way analysis of variance; MD = Mean difference

Clinical factors on diabetes self-efficacy

There was a significant negative correlation between left ventricular ejection fraction and diabetes self-efficacy scores, $r = -0.061$, $p = 0.034$ (Table 2). T2D-HF patients without end organ failure had significantly higher mean diabetes self-efficacy scores (*M* = 28.1±6.3) compared to those with end organ failure (*M* = 26.0±5.5), $t(168) = 2.002$, $p = 0.049$ (Table 2).

A one-way ANOVA was performed to examine the influence of T2D medications categories on diabetes self-efficacy (Table 2). Participants were divided into four medication categories (oral medication only, insulin only, both oral medication and insulin, and no to both). There were significant differences in diabetes self-efficacy scores for the four medication categories: *F* (3,

167) = 2.716, *p* = 0.046 and the effect size was large (0.95). Post-hoc comparisons support those who were not taking either oral medication or insulin (*M* = 29.8±6.5) had significantly better diabetes self-efficacy scores compared to those who were taking both oral medications and insulin (*MD* = 5.8, 95%CI: 0.0472 to 11.4528). Participants taking oral medication only (*M* = 28.1±6.9) and insulin only (*M* = 27.7±6.0) did not differ from those taking both oral medication and insulin or not taking both drugs (Table 2).

Table 2-0-2 Clinical characteristics of comorbid T2D-HF patients on diabetes self-efficacy (N = 180)

Characteristics	Overall n (%)	Perceived Diabetes Self-Management Scale Score	
		Mean ±SD	Test of Association
NYHA Functional class:			
Class I and II	70 (38.9%)	26.9 (5.9)	t = -1.076, df = 168, *p* = 0.284
Class III and IV	109 (60.6%)	28.0 (6.4)	
HF duration, y, mean ±SD	5.3 (5.9)	27.7 (6.2)	*r* = 0.104, *p* = 0.181
Ejection fraction, mean ±SD	33.6 (16.9)	27.7 (6.2)	*r* = -0.061, *p* = 0.034
DM management regimen/type:			
Diet alone	15 (8.3%)	29.9 (7.6)	t = 1.421, df = 168, *p* = 0.157
Diet plus medication	163 (90.6%)	27.4 (6.1)	
DM with end organ failure:			
No	137 (76.1%)	28.1 (6.3)	t = 2.002, df = 168, *p* = 0.049
Yes	42 (23.3%)	26.0 (5.5)	
DM duration, y, mean ±SD	11.1 (8.4)	27.7 (6.2)	*r* = -0.099, *p* = 0.199
Medication:			
Angiotensin-converting enzyme (ACE) inhibitor:			
No	81 (45.0%)	28.3 (6.3)	t = 1.144, df = 168, *p* = 0.254
Yes	97 (53.9%)	27.2 (6.2)	
Angiotensin receptor inhibitors (ARB):			
No	146 (81.1%)	29.9 (6.1)	t = 0.602, df = 161, *p* = 0.548
Yes	25 (13.9%)	27.0 (6.3)	
Beta-blockers:			
No	11 (6.1%)	28.4 (5.4)	t = 0.428, df = 168, *p* = 0.676
Yes	167 (92.8%)	27.6 (6.3)	
Digitalis:			
No	156 (86.7%)	27.8 (6.2)	t = 0.888, df = 167, *p* = 0.376
Yes	20 (11.1%)	26.4 (6.6)	
Diuretics:			
No	127 (70.6%)	27.5 (6.4)	t = -0.328, df = 164, *p* = 0.744
Yes	45 (25.0%)	27.8 (5.5)	
Loop diuretics:			
No	21 (11.7%)	28.4 (7.1)	t = 0.527, df = 169, *p* = 0.599
Yes	158 (87.8%)	27.6 (6.1)	
Aldosterone inhibitors:			
No	113 (62.8%)	27.9 (5.9)	t = 0.388, df = 155, *p* = 0.700
Yes	49 (27.2%)	27.5 (6.6)	
Total number of daily medication, mean ±SD	12.2 (3.9)	27.7 (6.2)	*r* = -0.078, *p* = 0.313
Oral diabetes medication:			
No, unknown or missing	114 (63.3%)	28.0 (6.1)	t = 1.048, df = 169, *p* = 0.296
Yes	66 (36.7%)	26.9 (6.5)	
Insulin:			
No, unknown or missing	66 (36.7%)	28.6 (6.8)	t = 1.408, df = 169, *p* = 0.161
Yes	114 (63.3%)	27.2 (5.9)	
Diabetes medication category:			
Oral medication only	48 (26.7%)	28.1 (6.9)	1-ANOVA = F (3, 167) = 2.716, p = 0.046
Insulin only	96 (53.3%)	27.7 (6.0)	***Sidak post hoc:*** No to both Vs Yes to both =
Both oral medication and insulin	18 (10.0%)	24.0 (4.3)	MD = 5.8, *p* = 0.047
No to both	18 (10.0%)	29.8 (6.5)	

r = Pearson's correlation coefficient; t = independent-sample t-test; 1-ANOVA = One –way analysis of variance; MD = Mean difference

Multimorbid conditions on diabetes self-efficacy

There were no statistically significant differences in the mean score of diabetes self-efficacy between participants who had more than two comorbid conditions and who had only two as evidenced by the Charlson comorbidity >2 (Table 3). Among other clinical variables, only hypertension was associated with diabetes self-efficacy. T2D-HF patients without comorbid hypertension had significantly higher diabetes self-efficacy scores (M = 32.1±7.2) than those without hypertension (M = 27.4±6.1), t (168) = 2.257, p = 0.025 (Table 3).

Table 2-0-3 Multimorbid conditions on diabetes self-efficacy in comorbid T2D-HF patients (N = 180)

Characteristics	Overall	Perceived Diabetes Self-Management Scale Score	
	n (%)	Mean ±SD	Test of Association
Charlson comorbidity index (CCI), mean ±SD	4.2 (2.3)	27.7 (6.2)	r = -0.093, p = 0.225
Charlson comorbidity > 2:			
No	47 (26.1%)	27.9 (6.1)	t = 0.366, df = 169, p = 0.715
Yes	133 (73.9%)	27.6 (6.3)	
Other comorbidities not in CCI:			
Depression history:			
No	136 (75.6%)	28.0 (6.4\0	t = 1.352, df = 167, p = 0.181
Yes	41 (22.8%)	26.6 (5.7)	
Hypertension:			
No	9 (5.0%)	32.1 (7.2)	t = 2.257, df = 168, p = 0.025
Yes	170 (94.4%)	27.4 (6.1)	
Arthritis:			
No	135 (75.0%)	27.9 (6.2)	t = 0.699, df = 167, p = 0.488
Yes	43 (23.9%)	27.1 (6.5)	
Coronary artery bypass grafting (CABG):			
No	142 (78.9%)	27.9 (6.3)	t = 1.118, df = 169, p = 0.268
Yes	38 (21.1%)	26.7 (5.9)	
History of valve repair:			
No	170 (94.4%)	27.8 (6.3)	t = 1.329, df = 167, p = 0.220
Yes	8 (4.4%)	25.3 (5.3)	
History of valve replacement:			
No	171 (95.0%)	27.5 (6.3)	t = -2.095, df = 169, p = 0.066
Yes	8 (4.4%)	30.5 (3.8)	
History of PTCA or PCI:			
No	128 (71.1%)	27.6 (6.5)	t = 0.056, df = 167, p = 0.955
Yes	50 (27.8%)	27.6 (5.7)	
History of stent:			
No	140 (77.8%)	27.7 (6.2)	t = 0.409, df = 168, p = 0.683
Yes	39 (21.7%)	27.2 (6.3)	
Dyslipidemia:			
No	83 (46.1%)	28.3 (6.5)	t = 1.434, df = 167, p = 0.153
Yes	94 (52.2%)	26.9 (5.4)	
Sleep apnea:			
No	115 (63.9%)	27.4 (6.4)	t = -0.646, df = 168, p = 0.520
Yes	64 (35.6%)	28.0 (6.1)	
Thyroid disorder:			
No	158 (87.8%)	27.6 (6.1)	t = -0.063, df = 168, p = 0.951
Yes	21 (11.7%)	27.7 (6.7)	
Exposure to chemotherapy:			
No	172 (95.6%)	27.8 (6.3)	t = 1.025, df = 167, p = 0.357
Yes	5 (2.8%)	25.8 (4.2)	
Pacemaker or device:			
No	152 (84.4%)	27.9 (6.2)	t = 1.163, df = 168, p = 0.246
Yes	27 (15.0%)	26.3 (6.6)	
Implantable cardioverter-defibrillator (ICD):			
No	105 (58.3%)	26.9 (6.1)	t = -1.834, df = 168, p = 0.069
Yes	72 (40.0%)	28.7 (6.3)	

r = Pearson's correlation coefficient; t = independent sample t-test; PTCA = Percutaneous transluminal coronary angioplasty; PCI = Percutaneous coronary intervention

Predictors of diabetes self-efficacy

A stepwise linear regression analysis was performed to explore the sociodemographic and clinical predictors of diabetes self-efficacy (Table 4). All theoretically relevant sociodemographic and clinical factors were put into the regression model. The F criterion of probability was 0.05 to enter and 0.10 to remove. Of the six models, the last one had the highest R-squared value (0.224) and thus selected as the final model. The variables in the model were perceived good health (β = 0.323, p < 0.001), taking both oral antiglycemic medication and insulin (β = 0.230,p< 0.01), depression history (β = -0.193, p< 0.05), having an internal cardiac defibrillator (ICD) (β = 0.283, p< 0.01), presence of a pacemaker (β = -0.184, p< 0.05), and taking digitals (β = -0.184, p< 0.05). These collectively explained 22.4% of the variation in diabetes self-efficacy scores: F (6, 124) = 5.98, p< 0.001.

A further analysis was conducted to explore the association between having an ICD with higher diabetes self-efficacy. In addition, we analyzed the correlation between having a pacemaker and taking digitalis with lower diabetes self-efficacy. Our analysis revealed that having an ICD was significantly associated with the NYHA class (X^2 = 5.72, p = 0.017) and diabetes end organ failure (X^2 = 4.06, p = 0.044).Participants who had a pacemaker had significant correlations with age (r_{bis} = 0.171, p = 0.022) and NYHA (X^2 = 5.78, p = 0.016) while digitalis use was significantly associated with diabetes end organ failure (X^2 = 4.08, p = 0.043) (data not shown in table).

Table 2-0-4 Results of stepwise multiple linear regression analysis predicting diabetes self-efficacy

Model	B	Std. Error B	β	R^2	ΔR^2	Collinearity Statistics	
						Tolerance	VIF
Constant	27.124	0.765					
Good health	4.145	1.070	0.323***	0.224	0.025*	0.902	1.109
Both oral medication and insulin	-4.743	1.070	-0.230**			0.976	1.024
Depression history	-2.706	1.118	-0.193*			0.984	1.016
ICD	3.456	1.071	0.283**			0.815	1.228
Pacemaker or device	-3.253	1.553	-0.184*			0.815	1.226
Digitalis	-3.329	1.650	-0.184*			0.913	1.095

ΔR^2 = R^2 change; *p< 0.05; **p< 0.01; ***p< 0.001

Discussion

Factors potentially influencing diabetes self-efficacy among individuals with T2D and comorbid HF have not been examined previously. The present study demonstrated both sociodemographic and clinical factors predicted diabetes self-efficacy in this population. African Americans were found to have poorer diabetes self-efficacy than their white counterparts indicating that they may be at higher risk for nonadherence to diabetes self-care and poorer clinical outcomes.

This study revealed that T2D-HF patients who rated their health status as good had a significantly higher diabetes self-efficacy score compared to fair or poor health status. The majority of participants however, rated their perceived health as fair to poor. This suggests that T2D-HF patients who rated their perceived health negatively thought they were less capable of performing diabetes self-care which may translate to poorer T2D and HF self-care and worse clinical outcomes. These findings support that self-rated health is an important antecedent of diabetes self-efficacy given previous findings from studies in other chronic illnesses (Grønning, Bratås, & Steinsbekk, 2016; Thompson, Mitchell, Johnson-Lawrence, Watkins, & Modlin, 2017; Weaver, Lemonde, & Goodman, 2014). Self-rated health provides a quick assessment that has been consistently shown to predict health outcomes in a number of chronic illnesses (Mavaddat, Valderas, Linde, Khaw, & Kinmonth, 2014; Perrucio, Katz, & Losina, 2012). Findings from this study indicate that poor perceived health status in particular, may provide an opportunity to examine other self-care behaviors such as medication and dietary adherence essential for better health outcomes in T2D and HF.

Participants who were receiving both oral antiglycemics and insulin had significantly lower diabetes self-efficacy scores. This may reflect higher illness burden and disease severity which may negatively influence an individual's capacity to perform effective self-care especially in the presence of other life-threatening chronic conditions such as HF (Sav et al., 2016). Managing multiple chronic conditions has been shown to lower diabetes self-efficacy and poorer clinical outcomes (Rogers et al., 2017; Rutten et al., 2016). Often patients are seeing multiple providers for their chronic conditions, which can lead to polypharmacy. Decreasing and simplifying the number of medications is an important strategy to lower overall illness burden and increase adherence. For example, having patients take one dose of medication instead of prescribing twice per day. The use of patient-centered models like Minimally Disruptive Medicine may help to reduce both treatment and comorbidity burdens and enhance patient's self-efficacy for diabetes management (Leppin, Montori, & Gionfriddo, 2015; Serrano, Spencer-Bonilla, Boehmer, & Montori, 2017).

In the current study, over 22% of participants were experiencing depressive symptoms higher than the general population. Depressive symptoms are well-established to be higher in chronic illnesses and have been shown to contribute to poorer health outcomes. Findings from this study shows depressive symptoms in comorbid T2D and HF predicted lower diabetes self-efficacy. The existence of depressive symptoms which is common in T2D and HF may lead to poorer health outcomes as a result of lower self-efficacy (Devarajoon & Chinna, 2017).Alleviating depressive symptoms could help to enhance patient's confidence and attention and ultimately improve diabetes self-efficacy. Routinely evaluating individuals with T2D and HF in outpatient settings using a brief assessment tool such as the Patient Health Questionnaire 9 (PHQ-9) may provide insightful information for clinicians for those at higher risk for poor adherence and ability to effectively and independently manage their self-care needs.

The present study identified that T2D-HF patients with ICD had significantly higher diabetes self-efficacy after adjusting for health status, multiple medications and depression history. An ICD has shown effectiveness in preventing sudden death in individuals with ischemic or non-ischemic HF (Theuns, Smith, Hunink, Bardy, & Jordaens, 2010). This survival benefit exists in patients with comorbid T2D and HF (Echouffo-Tcheugui, Masoudi, Bao, Spatz, & Fonarow, 2016; Shahreyar et al., 2015). An ICD may be a proxy either for higher NYHA class indicating worsening HF or diabetes end organ failure given its significant association with both outcomes. The survival benefit associated with ICD placement may improve outcome expectancy and serve as a pathway linking ICD with higher diabetes self-efficacy. The psychological distress often induced by an ICD (Shiga, Suzuki, & Nishmura, 2013) as well as conflicting clinical outcomes related to quality of life after ICD placement may further complicate the link between ICD and diabetes self-efficacy. Future research is needed to better understand the relationships in order to design effective interventions that lead tom improved outcomes in this complex patient population.

In contrast, pacemaker insertion and individuals taking digitalis had significantly lower diabetes self-efficacy. Mortality has been shown to be higher among those with a pacemaker who have co-existing T2D and HF and may not have the perceived survival benefit of an ICD (Sun et al., 2015; Udo et al., 2012). Digitalis improves end-points such as hospital admission for HF in patients with and without diabetes, but is associated with higher mortality, particularly among women (Abdul-Rahim et al., 2016; Eade, Cooper, & Mitchell, 2013; Ziff & Kotecha, 2016). Similar to ICD's, use of a pacemaker and taking digitalis are commonly associated with increasing age and more advanced HF, both of which are associated with lower self-efficacy and ability to participate in effective self-care. Future research is needed on these sub-groups that have increased morbidity and mortality since are likely to increase as the population ages.

Implication for research and practice

The usual approach for research in diabetes self-efficacy was largely disease-specific ignoring the influence of other comorbid conditions. But, as experts noted addressing diabetes self-efficacy in the context comorbid conditions may lead to more effective interventions(Dunbar et al., 2014; Smith et al., 2012). The present study found that T2D patients with comorbid HF with good perceived health rating and ICD had higher diabetes self-efficacy. Though the mechanism linking the latter to diabetes self-efficacy is unknown, perceived health rating may provide insight into which T2D and HF individuals are at highest risk for poor clinical outcomes.

Our study also found that taking both oral antiglycemic medication and insulin, history of depression, presence of pacemaker or device, and taking digitalis predicted lower diabetes self-efficacy. The negative effect of taking both oral antiglycemics and insulin may imply greater illness burden. Depressive symptoms are well-established to lead to poorer self-care in T2D and HF but are rarely evaluated in clinical settings. Identifying depressive symptoms and providing appropriate care to alleviate the symptoms may improve both self-care and self-efficacy and warrants future research. The mechanism linking an ICD, pacemaker and taking digitalis with diabetes self-efficacy is not clear but likely reflects advancing HF. Further studies are necessary to ascertain the pathways in which these variables influence diabetes self-efficacy.

Strength and limitations

The current study has several strengths and limitations. Strengths include our findings which support that the presence of other comorbid chronic illnesses are common in T2D and may result in suboptimal diabetes self-care (Lin et al., 2015). Future studies should consider the influence of multiple comorbidities and develop interventions to better integrate treatment regimens that promote effective self-care (Dunbar et al., 2014; Smith et al., 2012). Notably, previous research examining diabetes self-efficacy has not considered the influence of other comorbid chronic conditions (Bohanny et al., 2013; Cosansu & Erdogan, 2014; J. Gao et al., 2013; E.-H. Lee et al., 2016). Few studies have documented the patient's sense of confidence in multiple chronic conditions condition. A major strength of the current study was to look at diabetes self-efficacy in persons with HF a serious, life threatening condition. Future studies are needed to examine T2D with other serious conditions to determine similarities and differences on diabetes self-efficacy. The study was composed of predominately African American males so may not be applicable to other ethnicities or women. It is possible that some participants rated their health or responded in ways that reflected social desirability. As with any secondary analysis, use of instruments and variables were predetermined. Although this study controlled for covariates some level of biases possible. The cross-sectional design limits interpretation and does not allow for identifying temporal sequences of variables.

Conclusion

Adapting an integrated self-care framework as a conceptual framework, this study this study identified the predictors of diabetes self-efficacy in people with T2D and comorbid HF. The findings suggested that T2D-HF patients with good perceived health have higher diabetes self-efficacy and using self-rated health would provide a comprehensive patient-centered assessment to evaluate their health status. Our finding also suggested that paying attention to address treatment and comorbidity burden and alleviating depressive symptoms could help to improve diabetes self-efficacy in adults with T2D and comorbid HF. Moreover, the findings warrant the importance of further studies to ascertain the pathways linking presence of ICD, pacemaker, and taking digitalis with diabetes self-efficacy.

CHAPTER III

Article 2: Correlates of Self-Care Behaviors in Adults with Type 2 Diabetes and Comorbid Heart Failure

Authors:

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Abstract

Background: Adherence to the recommended self-care behaviors for type 2 diabetes (T2D) is essential for improving glycemic control and managing diabetes-related comorbidities such as heart failure (HF). The prevalence of heart failure is 2 to 3 times higher in persons with T2Dbut few studies have documented factors influencing self-care behaviors in T2D with comorbid HF.

Purpose: The purpose of this study was to describe demographic, clinical and psychosocial correlates of diabetes self-care behaviors (exercise, self-monitoring blood glucose [SMBG], and foot care) in patients with T2D and comorbid HF.

Method: Baseline data of 180 participants from a clinical trial that tested a 6-month integrated self-care intervention for adult persons with comorbid HF and T2D were analyzed. The Summary of Diabetes Self-Care Activities (SDSCA) was used to measure diabetes self-care behaviors. Correlational bivariate and multiple logistic regression analyses were performed to examine associations and the predictors of diabetes self-care behaviors.

Result: Participants had a mean age of 58±11years, the majority were male (n = 118, 66%) and African American (n = 119, 66%).Number of comorbidities>2 ($p<0.001$), having more than a high school education ($p< 0.05$) and African American ethnicity ($p< 0.05$) predicted better exercise, blood glucose testing, and foot care behaviors, respectively. The use of an aldosterone inhibitor($p< 0.05$) predicted worse exercise performance, higher Charlson comorbidity index scores ($p< 0.01$) predicted worse SMBG, and treatment with diet plus medication ($p< 0.05$) and dyslipidemia ($p< 0.001$) predicted worse foot care behaviors.

Conclusion: Findings from this study provide new insights into the complex self-care requirements for persons living with T2D and comorbid HF. Integrated self-care interventions are clearly warranted in persons living with multiple chronic conditions for optimal health outcomes and the prevention of complications. Our sample of predominately African American men showed they had better T2D self-care behaviors than whites than previously reported. Additional research is needed to determine racial and gender differences on health outcomes in persons with T2D, comorbid HF and other chronic conditions.

Keywords: type 2 diabetes, heart failure, diabetes self-care, exercise, blood glucose testing, foot care, comorbidity

Introduction

Driven by environmental, genetic, and lifestyle factors, type 2 diabetes mellitus (T2D) has emerged as one of the most prevalent health problems. Data from the NCD Risk Factor Collaboration (NCD-RisC) demonstrated that the number of adults with diabetes mellitus (DM) almost quadrupled from 1980 to 2014 worldwide (NCD-RisC, 2016). Recent estimates also showed that the number of people (age 18 – 99 years) with DM worldwide will increase from 451 million in 2017 to 693 million by 2045 (Cho et al., 2018). The rapid increase in DM prevalence poses tremendous personal, societal and economic burden (Cho et al., 2018).   More than 90% of the total DM cases are T2D (Holman et al., 2015; G. Xu et al., 2018). Persons with T2D have other comorbid conditions that may challenge their ability to practice effective self-care behaviors including self-monitoring blood glucose (SMBG), exercise, and foot care.

Heart failure (HF) is a major contributor to cardiovascular disease (CVD)morbidity and mortality in T2D (Lehrke & Marx, 2017). The prevalence of HF among individuals with T2D worldwide is 14.9% (Einarson et al., 2018) which is higher than the prevalence documented (1-12%) in the general US and European populations (Roger, 2013). Persons with T2D have a 2-3 fold higher incidence of HF compared to those without T2D (Nichols et al., 2004). Prognosis is also poorer among those with T2D who have comorbid HF (Bauduceau et al., 2018; Lehrke & Marx, 2017). Factors associated with increased risk of HF in T2D include coronary heart disease, chronic hyperglycemia, insulin use and advancing age (Wang et al., 2015). In addition, obesity, hypertension, dyslipidemia, anemia(Thomas, 2016) and microalbuminuria (Basi, Fesler, Mimran, & Lewis, 2008)also increase risk for HF development. Proper management of comorbid conditions and adherence to T2D self-care behaviors are key to preventing the development or progression of HF (Oktay et al., 2018).

Diabetes Self-Care Behaviors

Self-monitoring blood glucose

Performing effective diabetes self-care behaviors are essential for better health outcomes in T2D. Self-care is an evolutionary learning process with the development of expertise over time, transitioning from a passive recipient of care to an active participant (B. Paterson & S. Thorne, 2000). Although it increases the cost of care, SMBG helps to optimize treatment outcomes, allows patients to participate in the control and treatment of their disease, and enhances self-confidence and motivation for self-care (ADA, 2018b; Elgart, Gonzalez, Prestes, Rucci, & Gagliardino, 2016). It is also an important tool for guiding dietary selection and exercise, prevention of hyper/hypoglycemia, and selection of drug treatment (ADA, 2018b). Clinical trials have demonstrated that in insulin-treated T2D, SMBG significantly improves glycemic control and quality of life (L. Gao et al., 2016; Jl & Su, 2017). However, contradictory evidence also exists concerning the benefit of SMBG for non-insulin-treated T2D patients. Some studies described that SMBG significantly improved glycemic control (Blevins, 2013; Breland, McAndrew, Burns, Leventhal, & Leventhal, 2013) while a recent randomized trial reported no significant improvement of either glycemic control or quality of life in non-insulin-treated T2D patients (Young et al., 2017). Evidence supports that in T2D patients, increased frequency of SMBG is associated with meeting HbA1c target goals (Elgart et al., 2016). A number of barriers are reported that impede SMBG in T2D including stress related to high blood glucose readings, stigma, fear of needles and pain, cost of test strips and needles, inconvenient work place settings and lack of motivation, poor diabetes knowledge and lower diabetes self-efficacy (Ong, Chua, & Ng, 2014).

Foot care

Diabetic foot complications such as neuropathy and peripheral vascular disease are a widespread problem in T2D. Currently, foot ulcers occur in 6.3% of diabetes-related foot problems worldwide and are more common in males with T2D (Zhang et al., 2017). The incidence of lower extremity amputation in DM ranges from 46.1 to 9600 per 100,000 compared to 5.8 to 31 per 100,000 in the general population (Moxey et al., 2011). Peripheral arterial disease and neuropathy are the major risk factors for vascular complication and amputation (Boyko, Seeling, & Ahroni, 2018). The ADA recommends that all diabetic patients engage in foot self-care activities such as daily monitoring and keeping the feet clean, choosing the right shoes, smoking cessation and regular annual check-ups (ADA, 2018b). A systematic review revealed that proper foot self-care practice reduced the risk of injury, infection, and amputation in people with T2D (Bonner, Foster, & Spears-Lanoix, 2016; Netten et al., 2016). Adherence to the recommended foot self-care behaviors, however, are often poor in people with T2D (Rao Li et al., 2014; Natovich, Harman-Boehm, Margalit, Cukierman-Yaffe, & Kushnir, 2017). Foot self-care behaviors are reported to be influenced by sociodemographic factors including income, education and gender, body weight, attitude, and diabetes knowledge (D'Souza et al., 2016; Rao Li et al., 2014; Wendling & Beadle, 2015).

Exercise

Exercise is defined as a purposeful activity with the goal of improving health and wellness (Lumb, 2014). It has a beneficial effect on metabolic parameters of cardiovascular risk, including lipids and blood glucose, and plays a major role in the prevention and management of T2D and diabetes-related complications (Colberg et al., 2010; Lumb, 2014). Current guidelines recommend people with T2D perform moderate intensity exercise 3 to 5 days a week for a minimum of 30 minutes per day or 150 minutes per week (ADA, 2018c; Colberg et al., 2010; Hansen et al., 2013; Ryden et al., 2013). A systematic review and meta-analysis of randomized trials revealed that structured training of aerobic exercise, resistance exercise or the combination of both modes of more than 150 minutes per week were associated with greater reduction of HbA1c (Umpierre et al., 2011). Similarly, for those who can tolerate higher-intensity exercise was reported to have a greater reduction in HbA1c (Grace, Chan, Giallauria, Graham, & Smart, 2017; Liubaoerjijin, Terada, Fletcher, & Boule, 2016). Combined aerobic and resistance exercise was determined to be superior in improving glycemic control and cardiovascular risk factors than either mode alone (Mendes, Sousa, Reis, & Themudo-Barata, 2017; B. Pan et al., 2018; Schwingshackl, Missbach, Dias, Konig, & Hoffmann, 2014). Barriers for performing exercise include negative attitudes, physical limitations, costs, lack of transportation and poor or unsafe environment (Halali, Madavi, Jafarabadi, Mobasseri, & Namazi, 2016).

Theoretical framework

An integrated conceptual framework originally developed to guide heart failure self-care was adapted for use in this study (Dunbar et al., 2008). The integrated conceptual framework pooled together concepts from self-management theories and learning theories used in patient education for self-care. In this regard, it puts foreword the premise that demographic, clinical, and psychosocial factors including self-efficacy, knowledge about the disease, social support, and depression are antecedents influencing self-care behaviors. This conceptual framework also applies to the present study with the same antecedents that may influence diabetes self-care behaviors in T2D patients with comorbid HF (Figure 1). While studies have shown factors that may influence diabetes self-care behaviors, none have considered the potential influence of comorbid chronic conditions on diabetes

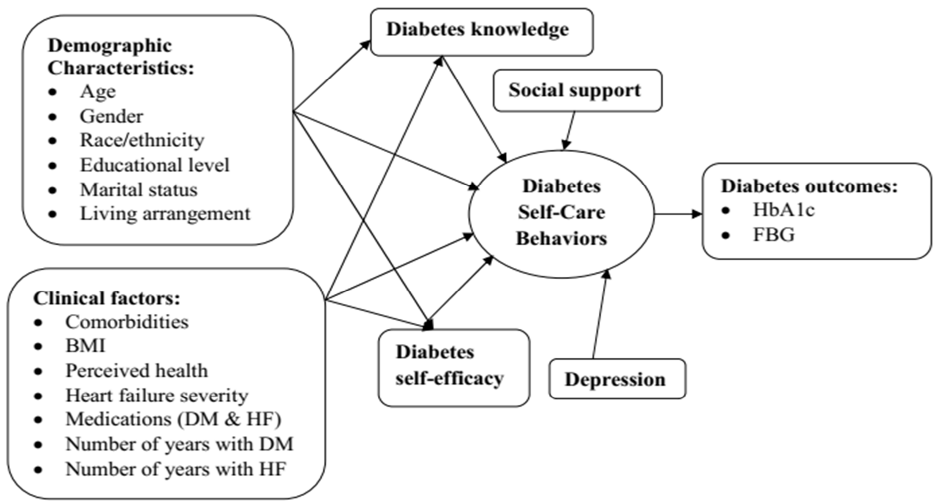

Figure 3-0-1 The conceptual model for diabetes self-care behaviors in adults with type 2 diabetes mellitus and comorbid heart failure. The model was adapted from the integrated conceptual framework for heart failure self-care research (Dunbar et al.2008)

self-care behaviors. To date, the one clinical trial that tested an integrated self-care program in persons with comorbid HF and T2D found significant improvement in diabetes exercise and foot self-care behaviors (Dunbar et al., 2014). The reason for the improvement in these self-care behaviors is unclear, but may imply that certain antecedent factors predict which T2D patients are more likely to adhere and engage in better self-care. Determining the individual and clinical characteristics that may predict better self-care are central components for designing more effective interventions among people with T2D and comorbid HF. The purpose of this study was to describe sociodemographic, clinical, and psychosocial predictors of diabetes self-care behaviors (SMBG, exercise and foot care,) in T2D adult patients with comorbid HF. More specifically, this study intended to answer the following research question: What sociodemographic, clinical, and psychosocial factors are associated with diabetes self-care behaviors in adults with T2D and comorbid HF?

Methods

Study design

A cross-sectional, correlational design was used for secondary analysis of baseline data from a randomized controlled trial (RCT) that tested a 6-month integrated self-care intervention for adults with comorbid HF and T2D (Dunbar et al., 2014; Dunbar et al., 2015). There was no overlap in method and data analysis from the originally published papers of the RCT except some variables. Unlike the previous publications(Dunbar et al., 2014; Dunbar et al., 2015) that looked at the effect of integrated self-care program on HF and DM self-care behaviors, the present study focused on elucidating factors correlated with diabetes self-care behaviors in the context of comorbid HF.

Participants

The parent randomized controlled trial enrolled adult patients with comorbid HF and T2D during hospitalization or within 3 months of discharge. Enrollment took place between 2010 and 2013 at 1 of 4 large urban-tertiary hospitals in the southeast. Study eligibility included: adults 21 to 80 years of age, currently hospitalized for HF or discharged within the past 3 months, New York Heart Association (NYHA) functional classification II-IV HF, comorbid T2D, were receiving medications according to current HF guidelines, ambulatory with no limitations that prevented exercise participation. Exclusion criteria were: newly diagnosed HF or first hospital admission, cognitive impairment a score of 11 or above on the Blessed Cognitive Tool (BCST), uncorrected hearing or vision problem, undergoing evaluation for cardiac transplant or evaluation for ventricular assist device, renal failure, and lack of telephone access, severe chronic pulmonary disease and stroke. The study was approved by the Institutional Review Board (IRB) at all participating institutions and participants provided written informed consent before study participation began.

The present study used Green's recommendation to determine sample size for multiple regression analysis (Green, 1991). Baseline data from180 participants were included in this study. This sample size has an effect size of 0.04, which is considered as small to medium and satisfied the requirement for a power of 0.80 based on Cohen's suggestion at statistical significance of 0.05 (Cohen, 1988).

Measurement

Sociodemographic and clinical information

The sociodemographic variables included were age, gender, race/ethnicity, marital status, education and living arrangement. Clinical variables included BMI, perceived health rating, NYHA functional classification, years since diagnosis of T2D and HF, left ventricular ejection fraction (LVEF), T2D, diabetes management regimen, medications, and presence of comorbid conditions. The Charlson comorbidity index (CCI), was used to measure the number of chronic conditions (Charlson et al., 1987).

Diabetes self-care behaviors

The Summary of Diabetes Self-Care Activities (SDSCA) were used to measure SMBG, exercise and foot self-care behaviors (Toobert et al., 2000). The SDSCA has 2-items each for exercise, SMBG, and foot care measurement. Participants report how many days in the previous week they have engaged in a particular diabetes self-care behavior and scores are calculated for each dimension. A score > 0 for exercise and 7 for SMBG and foot care per week are considered effective for performing diabetes self-care behaviors. Cronbach's alphas are reported to be 0.83 for exercise, 0.92 for blood glucose testing, and 0.77 for foot care (Aljohani et al., 2016).

Diabetes self-efficacy

The Perceived Diabetes Self-Management Scale (PDSMS) was used to measure diabetes self-efficacy (Wallston et al., 2007). The PDSMS is an 8-item scale with the responses for each item ranging from 1 (strongly disagree) to 5 (strongly agree). The total scale score ranges from 8 to 40. A higher score shows more confidence in managing diabetes. The PDSMS has adequate reliability with Cronbach's alpha's ranging from 0.83 to 0.93 (Al-Aboud, Ahmad, Bidin, & Ismail, 2016).

Diabetes knowledge

The Michigan Diabetes Knowledge Test (DMKT) was used to measure the participants' knowledge of diabetes (Fitzgerald et al., 2016). The DMKT consists of 14-item and scored based on the percent of questions answered correctly. It has adequate reported reliability with a Cronbach's alpha of 0.71 (Fitzgerald et al., 2016).

Depression

The Patient Health Questionnaire-9 (PHQ-9) was used to screen for depressive symptoms (Kroenke et al., 2001). It is a 9-item instrument that documents the presence of depressive symptoms. Each item is rated as 0 (indicating not at all) to 3 (nearly every day). Scores may range from 0 to 27, with a score of ≤4 indicating mild, 5-14 moderate and >14 severe depressive symptoms. The scale has adequate internal reliability with a Cronbach's alpha of 0.89 to 0.91, and sensitivity and specificity of88% to 98%respectively (Yaung et al., 2008).

Social support

The ENRICHD Social Support Instrument (ESSI) was used to assess social support available to participants (ENRICHD, 2000). The ESSI is a 7-item questionnaire that measures perceived social support. Individual items are summed for a total score ranging from 7 to 35, with higher score indicating greater social support. The ESSI has demonstrated acceptable internal consistency with a Cronbach's alpha range of 0.86 to 0.88 (Vaglio et al., 2004).

Data analysis

Before analysis, the data were examined for accuracy, completeness, potential outliers, and missing values. Bivariate analysis using Biseral correlation and Chi-square test of independence were performed to determine the demographic, clinical and psychosocial variables relationships with diabetes self-care behaviors. Forward stepwise logistic regression along with likelihood ratios was used to explore the predictors of diabetes self-care behaviors including, exercise, and SMBG. To facilitate the analysis the outcome were dichotomized and coded binary. Exercise behavior was coded 1 if performed at least 1 day per week and coded 0 if not performed at least 1 day per week. Both SMBG and foot care behaviors were coded 1 if performed 7 days a week and coded 0 if performed for less than 7 days a week. A 95% confidence interval and p-value < 0.05 were used to determine statistical significance. The Cox and Snell R square and Nagelkerke square values were used to estimate variance explained in the outcomes variables. Adapting Wald's Chi-square test for the regression parameter estimation, an odds ratio (e^B) was applied to test and evaluate the fit of each condition in the model. An odds ratio (OR) < 1 was defined as predictor(s) of less performance and OR > 1 as high performance of SMBG exercise, and foot care. The IBM SPSS for Windows version 24 was used to analyze the data.

Results

Tables 1, 2, and 3 summarize participant characteristics and the strength of bivariate correlations between sociodemographic, clinical and psychosocial variables and diabetes self-care behaviors (exercise, SMBG and foot care). Table 4 summarizes the findings from stepwise multiple logistic regression analysis.

Participants

The mean age of the study participants was 58±11 years (Table 1), the majority were male (n= 118, 66%) and African American (n= 119, 66%). Most had more than a high school education (n = 114, 63%) and lived with a spouse or children (n = 116, 64%).The mean number of years since diagnosis of T2D was 11±8 and heart failure was 5±6 (Table 2). Clinically, the mean left ventricular ejection fraction (LVEF) was 33.6 ± 16.9, and the average number of medications taken was 12±4 and most had 4±2 chronic conditions (Table 3). The mean diabetes self-efficacy score was 27.7±6.2, depression symptoms 6.7±4.4, diabetes knowledge 57.9±18 and social support 27.9±5.8 (Table 1).

Demographic, psychosocial factors and diabetes self-care behaviors

The bivariate analysis revealed that there was a significant negative correlation between BMI and exercise, $r_{\text{bis}} = -0.230$, $p = 0.002$. Diabetes self-efficacy was significantly associated with exercise, $r_{\text{bis}} = 0.236$, $p = 0.002$. There was significantly negative correlation between depression and foot care performance, $r_{\text{bis}} = -0.181$, p = 0.016 (Table 1).

Chi-square test of independence revealed significant relationships between foot care and gender, X^2 (1, N = 171) = 5.87, $p = 0.015$, race, X^2 (1, N = 175) = 8.046, $p = 0.003$ and living arrangements X^2 (2, N = 175) = 6.071, $p = 0.048$. The relationship between perceived health rating and exercise was also significant, X^2 (2, N = 172) = 3.559, $p = 0.001$ (Table 1).

Table 3-0-1 Demographic and psychosocial characteristics of comorbid T2D-HF patients on diabetes self-care behaviors of exercise, blood glucose testing, and foot care (N = 180)

Characteristics	Overall n (%)	Exercise		Blood Glucose Testing		Foot Care	
		n (%)	Test of Association	n (%)	Test of Association	n (%)	Test of Association
Age, y, mean ±SD	58.1 (10.7)		r_{bis} = 0.123, p = 0.106		r_{bis} = 0.017, p = 0.821		r_{bis} = -0.122, p = 0.107
Sex:							
Female	62 (34.4%)	60 (34.3%)	X^2= 1.27, df = 1, p = 0.268	59 (33.9%)	X^2 = 1.776, df = 1, p = 0.183	60 (34.3%)	X^2 = 5.867, df = 1, p = 0.015
Male	118 (65.6%)	115 (65.7%)		115 (66.1%)		115 (65.7%)	
Race:							
None-AA (White, Asian)	61 (33.9%)	59 (33.7%)	X^2 = 1.98, df = 1, p = 0.161	59 (33.9%)	X^2 = 0.479, df = 1, p = 0.489	58 (33.1%)	X^2 = 8.646, df = 1, p = 0.003
African American (AA)	119 (66.1%)	116 (66.3%)		115 (66.1%)		117 (66.9%)	
Marital status:							
Single/divorced/widowed	90 (50.0%)	87 (49.7%)	X^2 = 0.003, df =1, p = 0.953	86 (49.4%)	X^2 = 0.578, df = 1, p = 0.442	87 (49.7%)	X^2 = 0.989, df = 1, p = 0.320
Married/domestic partner	90 (50.0%)	88 (50.3%)		88 (50.6%)		88 (50.3%)	
Education:							
≤ High school	65 (36.1%)	63 (36.2%)	X^2 = 1.018, df = 1, p = 0.313	63 (36.4%)	X^2 = 0.283, df = 1, p = 0.595	63 (36.2%)	X^2 = 0.030, df = 1, p = 0.862
> High school	114 (63.3%)	111 (63.8%)		110 (63.6%)		111 (63.8%)	
Living arrangement:							
Live alone	41 (22.8%)	40 (22.9%)		40 (23.0%)		40 (22.9%)	
Live with spouse/children	116 (64.4%)	113 (64.5%)	X^2 = 5.226, df = 2, p = 0.073	112(64.4%)	X^2 = 3.332, df = 2, p = 0.190	113 (64.5%)	X^2 = 6.071, df = 2, p = 0.048
Live with siblings/relatives	23 (12.8%)	22 (12.6%)		22 (12.6%)		22 (12.6%)	
BMI, kg/m^2, mean ±SD	36.7 (8.9)		r_{bis} = -0.230, p = 0.002		r_{bis} = 0.034, p = 0.659		r_{bis} = 0.049, p = 0.523
Perceived health rating:							
Poor	53 (29.4%)	52 (30.2%)		51 (30.0%)		51(29.8%)	
Fair	73 (40.6%)	71 (41.3%)	X^2 = 13.559, df = 2, p = 0.001	71 (41.8%)	X^2 = 1.817, df = 2, p = 0.403	71 (41.5%)	X^2 = 0.931, df = 2, p = 0.628
Good	49 (27.2%)	49 (28.3%)		48 (28.2%)		49 (28.7%)	
Depression, mean ±SD	6.7 (4.4)		r_{bis} = 0.036, p = 0.638		r_{bis} = 0.054, p = 0.483		r_{bis} = -0.181, p = 0.016
Social support, mean ±SD	27.9 (5.8)		r_{bis} = -0.046, p = 0.625		r_{bis} = 0.035, p = 0.713		r_{bis}= 0.141, p = 0.130
Self-efficacy, mean ±SD	27.7 (6.2)		r_{bis} = 0.236, p = 0.002		r_{bis} = 0.057, p = 0.458		r_{bis}= 0.129, p = 0.095
Diabetes knowledge	57.9 (18.2)		r_{bis} = -0.012, p = 0.870		r_{bis} = -0.071, p = 0.355		r_{bis} = -.053, p = 0.485

r_{bis} = Biserial correlation; X^2 = Chi-square test

Clinical factors and diabetes self-care behaviors

Significant relationships were found between exercise and the use of angiotensin-converting enzyme inhibitors (ACEI), X^2 (1, N = 174) = 6.752, p = 0.009 and beta blockers [X^2 (1, N = 174) = 4.148, p = 0.042]. There were also significant associations between foot care and ACEI, X^2 (1, N = 174) = 5.425, p = 0.020 and beta blockers. X^2 (1, N = 174) = 6.039, p = 0.014. The relationship between insulin use and exercise was also significant, X^2 (1, 175) = 4.332, p = 0.037 (Table 2).

Table 3-0-2 Clinical characteristics of comorbid T2D-HF patients on diabetes self-care behaviors of exercise, blood glucose testing, and foot care (N = 180)

Characteristics	Overall n (%)	Exercise		Blood Glucose Testing		Foot Care	
		n (%)	Test of Association	n (%)	Test of Association	n (%)	Test of Association
NYHA Functional class:							
Class I and II	70 (38.9%)	68 (39.1%)	X^2 = 0.037, df = 1, p = 0.848	67 (38.7%)	X^2 = 1.329, df = 1, P = 0.249	67 (38.5%)	X^2= 3.217, df = 1, p = 0.073
Class III and IV	109 (60.6%)	106 (60.9%)		106 (61.3%)		107 (61.5%)	
HF duration, y, mean ±SD	5.3 (5.9)		r_{bis} = -0.016, p = 0.840		r_{bis} = 0.053, p = 0.494		r_{bis} = 0.085, p = 0.271
Ejection fraction, mean ±SD	33.6 (16.9)		r_{bis} = -0.048, p = 0.532		r_{bis} = 0.013, p = 0.869		r_{bis} = 0.055, p = 0.478
DM duration, y, mean ±SD	11.1 (8.4)		r_{bis} = -0.022, p = 0.777		r_{bis} = -0.012, p = 0.880		r_{bis} = 0.009, p = 0.902
DM with end organ failure:							
No	137 (76.1%)	133 (76.4%)	X^2 = 0.027, df = 1, p = 0.869	132 (76.3%	X^2 = 0.440, df = 1, p = 0.507	134 (77.0%)	X^2 = 1.388, df = 1, p = 0.239
Yes	42 (23.3%)	41 (23.6%)		41 (23.7%)		40 (23.0%)	
DM management regimen:							
Diet alone	15 (8.3%)	15 (8.6%)	X^2 = 2.113, df = 1, p = 0.146	15 (8.7%)	X^2 = 0.696, df = 1, p = 0.404	15 (8.6%)	X^2 = 1.654, df = 1, p = 0.198
Diet plus medication	163 (90.6%)	159 (91.4%)		158 (91.3%)		159 (91.4%)	
ACE inhibitor use:							
No	81 (45.0%)	77 (44.3%)	X^2 = 6.752, df = 1, p = 0.009	77 (44.5%)	X^2 = 0.314, df = 1, p = 0.575	78 (44.8%)	X^2 = 5.425, df = 1, p = 0.020
Yes	97 (53.9%)	97 (55.7%)		96 (55.5%)		96 (55.2%)	
ARB use:							
No	146 (81.1%	11 (50.0%)	X^2 = 1.692, df = 1, p = 0.193	11 (52.4%)	X^2 = 2.291, df = 1, p = 0.130	11 (50.0%)	X^2 = 0.786, df = 1, p = 0.375
Yes	25 (13.9%)	11 (50.0%)		10 (47.6%)		11 (50.0%)	
Beta blockers use:							
No	11 (6.1%)	11 (6.3%)	X^2 = 4.148, df = 1, p = 0.042	10 (5.8%)	X^2 = 3.748, df = 1, p = 0.053	11 (6.3%)	X^2 = 6.039, df = 1, p = 0.014
Yes	167 (92.8%)	163 (93.7%)		163 (94.2%)		163 (93.7%)	
Digitalis use:							
No	156 (86.7%)	154 (89.0%)	X^2 = 0.269, df = 1, p = 0.604	153 (89.0%)	X^2 = 0.018 , df = 1, p = 0.892	154 (89.0%)	X^2 = 0.141, df = 1, p = 0.707
Yes	20 (11.1%)	19 (11.0%)		19 (11.0%)		19 (11.0%)	
Aldosterone inhibitors use:							
No	113 (62.8%)	111 (69.8%)	X^2 = 0.181, df = 1, p = 0.671	110 (69.6%)	X^2 = 0.310, df = 1, p = 0.579	110 (69.2%)	X^2 = 0.152, df = 1, p = 0.697
Yes	49 (27.2%)	48 (30.2%)		48 (30.4%)		49 (30.8%)	
Diuretics use:							
No	127 (70.6%)	125 (73.1%)	X^2= 1.088, df = 2, p = 0.580	124 (73.4%)	X^2= 2.572, df = 2, p = 0.276	124 (72.9%)	X^2 = 0.954, df = 2, p = 0.621
Yes	45 (25.0%)	45 (26.3%)		44 (26.0%)		45 (26.5%)	
Loop diuretics use:							
No	21 (11.7%)	20 (11.4%)	X^2= 0.050, df = 1, p = 0.823	20 (11.5%)	X^2 = 3.411, df = 1, p = 0.065	20 (11.4%)	X^2 = 2.872, df = 1, p = 0.090
Yes	158 (87.8%)	155 (88.6%)		154 (88.5%)		155 (88.6%)	
Total daily medication, mean ±SD	12.2 (3.9)		r_{bis} = 0.010, p = 0.900		r_{bis} = 0.061, p = 0.422		r_{bis} = 0.060, p = 0.430
Oral DM medication use:							
No, unknown or missing	114 (63.3%)	112 (64.0%)	X^2 = 3.503,df = 1, p = 0.061	112 (64.4%)	X^2 = 0.013, df = 1, p = 0.910	112 (64.0%)	X^2 = 3.503, df = 1, p = 0.061
Yes	66 (36.7%)	63 (36.0%)		62 (35.6%)		63 (36.0%)	
Insulin use:							
No, unknown or missing	66 (36.7%)	62 (35.4%)	X^2 = 4.332 , df = 1, p = 0.037	61 (35.1%)	X^2 = 2.376, df = 1, p = 0.123	63 (36.0%)	X^2 = 0.804, df = 1, p = 0.370
Yes	114 (63.3%)	113 (64.6%)		113 (64.9%)		112 (64.0%)	
DM medication category:							
Oral medication only	48 (26.7%)	45 (25.7%)	X^2 = 6.697, df = 1, p = 0.082	44 (25.3%)	X^2 = 4.026, df = 3, p = 0.259	46 (26.3%)	X^2 = 3.779, df = 3, p = 0.286
Insulin only	96 (53.3%)	95 (54.3%)		95 (54.6%)		95 (54.3%)	
Both oral and insulin	18 (10.0%)	18 (10.3%)		18 (10.3%)		17 (9.7%)	
No to both	18 (10.0%)	17 (9.7%)		17 (9.8%)		17 (9.7%)	

r_{bis} = Biserial correlation; X^2 = Chi-square test

Multi-morbid conditions and diabetes self-care behaviors

There were significant relationships between exercise and a CCI score > 2 X^2 (1, N = 175) = 9.132, p = 0.003 and hypertensionX^2 (1, N = 174) = 5.660, p = 0.017. Dyslipidemia and foot care were also significantly correlated, X^2 (1, N = 172) = 15.808, p< 0.001(Table 3).

Table 3-0-3 Multimorbid conditions on diabetes self-care behaviors of exercise, blood glucose testing, and foot care in patients with comorbid T2D-HF (N = 180)

Characteristics	**Overall**	**Exercise**		**Blood Glucose Testing**		**Foot Care**	
	n (%)	**n (%)**	**Test of Association**	**n (%)**	**Test of Association**	**n (%)**	**Test of Association**
CCI, mean ±SD	4.2 (2.3)		r_{bis} = 0.063, p = 0.406		r_{bis} = -0.106, p = 0.163		r_{bis} = -0.115, p = 0.130
Number of comorbidities> 2:							
No	47 (26.1%)	44 (25.1%)	X^2 = 9.132, df = 1,	45 (25.9%)	X2 = 0.185, df =	45 (25.7%)	X^2 = 1.168, df =
Yes	133 (73.9%)	131 (74.9%)	p = 0.003	129 (74.1%)	1, p = 0.667	130 (74.3%)	1, p = 0.280
Depression history							
No	136 (75.6%)	133 (76.9%)	X^2= 1.092, df = 1,	131 (76.6%)	X^2 = 0.355, df =	132 (76.7%)	X^2 = 1.346, df =
Yes	41 (22.8%)	40 (23.1%)	p = 0.296	40 (23.4%)	1, p = 0.551	40 (23.3%)	1, p = 0.246
Hypertension:							
No	9 (5.0%)	9 (5.2%)	X^2 = 5.660, df = 1,	9 (5.2%)	X^2 = 0.105, df =	9 (5.2%)	X^2 = 0.085, df =
Yes	170 (94.4%)	165 (94.8%)	p = 0.017	164 (94.8%)	1, p = 0.746	165 (94.8%)	1, p = 0.770
Arthritis:							
No	135 (75.0%)	130 (75.1 %)	X^2 = 0.001, df = 1,	129 (75.0%)	X^2 = 0.031, df =	131 (75.7%)	X^2 = 3.063, df =
Yes	43 (23.9%)	43 (24.9%)	p = 0.973	43 (25.0%)	1, p = 0.860	42 (24.3%)	1, p = 0.080
CABG:							
No	142 (78.9%)	137 (78.3%)	X^2 = 0.064, df = 1,	137 (78.7%)	X^2 = 0.718, df =	138 (78.9%)	X^2 = 0.000, df =
Yes	38 (21.1%)	38 (21.7%)	p = 0.800	37 (21.3%)	1, p = 0.397	37 (21.1%)	1, p = 0.986
History of valve repair:							
No	170 (94.4%)	165 (95.4%)	X^2 = 0.565, df = 1,	164 (95.3%)	X^2 = 0.574, df =	165 (95.4%)	X^2= 0,615, df =
Yes	8 (4.4%)	8 (4.6%)	p = 0.452	8 (4.7%)	1, p = 0.449	8 (4.6%)	1, p = 0.433
History of valve replacement:							
No	171 (95.0%)	167 (95.4%)	X^2 = 2.269, df = 1,	165 (95.4%)	X^2 = 0.003, df =	166 (95.4%)	X^2 = 0.001, df =
Yes	8 (4.4%)	8 (4.6%)	p = 0.132	8 (4.6%)	1, p = 0.960	8 (4.6%)	1, p = 0.979
History of PTCA or PCI:							
No	128 (71.1%)	125 (72.3%)	X^2 = 0.622, df = 1,	123 (71.5%)	X^2 = 1.398, df =	124 (71.7%)	X^2 = 0.346, df =
Yes	50 (27.8%)	48 (27.7%)	p = 0.430	49 (28.5%)	1, p = 0.237	49 (28.3%)	1, p = 0.556
History of stent:							
No	140 (77.8%)	135 (77.6%)	X^2 = 0.684, df = 1,	134 (77.5%)	X^2 = 0.003, df =	135 (77.6%)	X^2 = 0.348, df =
Yes	39 (21.7%)	39 (22.4%)	p = 408	39 (22.5%)	1, p = 0.953	39 (22.4%)	1, p = 0.555
Dyslipidemia:							
No	83 (46.1%)	83 (48.3%)	X^2 = 0.040, df = 1,	82 (48.0%)	X^2 = 3.157, df =	83 (48.3%)	X^2 = 15.808, df
Yes	94 (52.2%)	89 (51.7%)	p = 0.842	89 (52.0%)	1, p = 0.076	89 (51.7%)	= 1, p = 0.000
Sleep apnoea:							
No	115 (63.9%)	110 (63.2%)	X^2 = 0.055, df =	110 (63.6%)	X^2 = 0.000, df =	111 (63.8%)	X^2 = 1.018, df =
Yes	64 (36.6%)	64 (36.8%)	1, p = 0.814	63 (36.4%)	1, p = 0.988	63 (36.2%)	1, p = 0.313
Thyroid disorder:							
No	158 (87.8%)	153 (87.9%)	X^2 = 2.118, df = 1,	152 (87.9%)	X^2 = 0.042, df =	153 (87.9%)	X^2 = 2.304, df =
Yes	21 (11.7%)	21 (12.1%)	p = 0.146	21 (12.1%)	1, p = 0.838	21 (12.1%)	1, p = 0.129
Exposure to chemotherapy:							
No	172 (96.6%)	168 (97.1%)	X^2 = 4.086, df = 1, p = 0.043	167 (97.1%)	X^2 = 0.206, df = 1, p = 0.650	168 (97.1%)	X^2 = 0.013, df = 1, p = 0.909
Yes	5 (2.8%)	5 (2.9%)		5 (2.9%)		5 (2.9%)	
Pacemaker or devise:							
No	152 (84.4%)	148 (85.1%)	X^2 = 0.016, df = 1,	148 (85.5%)	X^2 = 0.308, df =	148 (85.1%)	X^2 = 0.567, df =
Yes	27 (15.0%)	26 (14.9%)	p = 0.899	25 (14.5%)	1, p = 0.579	26 (14.9%)	1, p = 0.452
ICD:							
No	105 (58.3%)	102 (59.0%)	X^2 = 0.047, df = 1,	102 (59.3%)	X^2 = 0.034, df =	102 (59.0%)	X^2 = 0.286, df =
Yes	72 (40.0%)	71 (41.0%)	p = 0.829	70 (40.7%)	1, p = 0.854	71 (41.0%)	1, p = 0.593

CCI = Charlson Comorbidity Index; r_{bis} = Biserial correlation; CABG = Coronary artery bypass grafting; ICD = Implantable cardioverter-defibrillator; X^2 = Chi-square test

Predictors of diabetes self-care behaviors

SMBG

Stepwise logistic regression was performed to explore the demographic, clinical, and psychosocial variables predicting diabetes self-care behaviors (Table 4). Greater than a high school education and CCI score was significant, X^2 (2, N = 94) = 12.06, p = 0.002, indicating that the model was able to distinguish between participants who undertook SMBG for 7 days a week and those who did it for less than 7 days a week. The model as a whole explained between 11.9% (Cox and Snell R Square) and 15.9% (Nagelkerke R Square) of the variance in SMBG, and classified 65.3% of observed cases of SMBG. In this model, having more than high school education and CCI were strong predictors of SMBG with odds ratios of 2.89 and 0.69, respectively. Participants who had more than high school education were about 3 times more likely to undertake SMBG for 7 days of a week compared to those who had less or equal to high school education. For each additional comorbid condition, participants were 1.45 times less likely to perform SMBG for 7 days of a week.

Exercise

The use of an aldosterone inhibitor and a CCI score >2 was statistically significant, X^2(2, N = 95) = 17.25, p< 0.001, showing that the model was able to distinguish between participants who exercise from those who were sedentary (Table 4). The model explained between 16.4% (Cox and Snell R Square) and 22.8% (Nagelkerke R Square) of the variance in exercise, and classified 72.9% of the observed cases of exercise. In this model, the odds of not exercising was 2.78 times higher for each 1 unit increase in the use of an aldosterone inhibitor while the odds of exercising was 6.21 times higher for each additional comorbid condition.

Foot Care

Dyslipidemia, African American race, and diabetes management with diet plus medication were significant predictors of foot care, X^2 (4, N = 92) = 25.33, p< 0.001,and explained between 23.4% (Cox and Snell R Square) and 31.6% (Nagelkerke R Square) of the variance in foot self-care as shown in Table 4. In this model, only three independent variables (dyslipidemia, African American race, and diabetes management with diet plus medication) were strong predictors of foot self-care for 7 days a week, with odds ratios of 0.15, 3.57, and 0.09 respectively. African

American participants compared to Whites were about 4 times more likely to perform foot care 7 days a week, controlling for other variables in the model. In addition, T2D-HF patients with dyslipidemia and those managed with diet plus medications were 6.7 and 11 times less likely to perform foot care respectively, for 7 days a week. Further analysis revealed that dyslipidemia had significant association with age (r_{bis} =0.317, p = 0.000) and NYHA (X^2 = 7.507, p = 0.006) while patient management with diet plus medication had significant correlations with years since T2D diagnosed (r_{bis} = 0.212, p = 0.005) (data not shown in table).

Table 3-0-4 Stepwise logistic regression predicting the likelihood of exercise, blood glucose testing, and foot care

Predictor	B	SE	Wald's X^2	Df	*p*-vale	Odds Ratio (e^B)	95% Confidence Interval
Exercise:							
Aldosterone inhibitor used (1)	-1.024	0.500	4.20	1	0.040	0.36	0.14 – 0.96
Number of comorbidities > 2 (1)	1.827	0.509	12.86	1	0.000	6.21	2.29 – 16.86
Constant	-0.136	0.417	0.11	1	0.743	0.87	
Blood glucose testing:							
Education > high school (1)	1.060	0.503	4.45	1	0.035	2.89	1.08 – 7.73
Charlson comorbidity index	-0.368	0.129	8.19	1	0.004	0.69	0.54 – 0.89
Constant	0.543	0.535	1.03	1	0.311	1.72	
Foot care:							
African American race (1)	1.274	0.575	4.91	1	0.027	3.57	1.16 – 11.02
Years with T2D	0.055	0.029	3.75	1	0.053	1.06	0.99 – 1.12
DM managed with diet plus med. (1)	-2.413	1.041	5.37	1	0.020	0.09	0.01 – 0.09
Dyslipidemia(1)	-1.872	0.537	12.16	1	0.000	0.15	0.05 – 0.44
Constant	1.141	1.129	1.02	1	0.312	3.13	

Discussion

This study is significant because it is one of the first to examine the sociodemographic, clinical and psychosocial correlates of self-care behaviors in persons with T2D-HF. The majority of participants were African American men who are disproportionately affected by T2D and are reported to have poorer diabetes self-care behaviors, glycemic control and worse clinical outcomes (Trief et al., 2013). The present study, however, contradicts these findings with African Americans more likely to adhere to the recommended foot self-care behaviors than their White counterparts. The reasons participants may have been more adherent in the current study are unclear but may reflect demographic differences since the majority were well-educated, had insurance coverage and self-reported the presence of strong social support. Men have reported higher levels of diabetes care–related social support and greater satisfaction with the support received than women with T2D (Tang, Brown, Funnell, & Anderson, 2008). Several studies have also found that among African Americans, social support is a major factor that distinguishes between those who are successful or unsuccessful in managing T2D self-care behaviors. Of particular importance is prior exposure to diabetes self-care practices and observational learning from family and friends that are successfully managing their diabetes (Madden et al., 2011). For persons with T2D-HF without adequate social support, educational groups that promote observational learning and utilize positive role models may be beneficial for improving participation and adherence to diabetes self-care and clinical outcomes (Trento et al., 2001).

Consistent with other studies, the present study found that T2D-HF patients who had greater than a high school education had better adherence to the recommended SMBG (Raoufi et al., 2018). Persons with T2D-HF with lower levels of education may have difficulty understanding the value of SMBG or lack the necessary skills to perform the test. Lower educational level may also increase barriers for performing blood glucose testing such as poor diabetes knowledge and self-care efficacy (Ong et al., 2014). Fewer economic resources or lack of information on how to use available resources for obtaining supplies necessary for SMBG is more common in those with lower education. Evaluating available resources, identifying barriers to self-care and tailoring diabetes self-care education to the patient's level of understanding is essential for better management and preventing complications associated with T2D.

Participants in this study with higher CCI scores were less likely to perform SMBG which has been previously reported (Bos-Touwen et al., 2015). It is possible that each additional chronic illness may potentially complicate diabetes self-care management, increase psychological and financial burden and may have reduced motivation for performing diabetes self-care (Miller & Rollnick, 2013). Greater disease burden likely contributed to increased depressive symptoms and lower perceived health status among our participants. Depression is more common in persons with T2D and HF and is associated with poorer adherence to self-care practices, prescribed treatment regimens and worse clinical outcomes. Because depressive symptoms are more common in chronic conditions, screening is imperative and should be routinely conducted in clinical practice settings (Semenkovich, Brown, Svrakic, & Lustman, 2015). If depressive screening scores indicate moderate to severe depressive symptoms a more comprehensive evaluation is warranted. A comprehensive assessment and evaluation of comorbidities (ADA, 2018a) may improve adherence with SMBG among persons with T2D and comorbid HF. Often persons with T2D or HF are managed by specialists who target disease specific self-care management and treatment regimens. Primary care clinicians are in a unique position to focus on providing self-management support and educational strategies that integrates the self-care needs of T2D-HF as well as other comorbidities.

Our findings showed that persons with T2D-HF with more than 2 chronic conditions were more likely to adhere to an exercise regimen (Medagama & Galgomuwa, 2018). As Berverily and colleagues reported (Beverily, Wray, Chiu, & Weinger, 2011), the presence of more comorbid conditions may have motivated our study participants to be more attentive to exercise as a strategy to reduce T2D and HF progression and the associated adverse events. In addition, clinicians in urban academic health science settings may be more likely to recommend and encourage exercise to improve health outcomes than those in rural or disadvantaged settings (Carroll et al., 2016). In addition, persons with greater social support are reported to engage in physical activity more frequently and experienced less diabetes-related distress (Tang et al., 2008). In addition, use of simple activity tracking devices are useful to set exercise goals or daily steps have been shown to improve exercise participation in persons with T2D and HF (Alharbi, Straiton, & Gallagher, 2017; Miyauchi et al., 2016). The low cost of most activity trackers make them accessible for most persons living with T2D-HF.

There was a significant relationship between the use of aldosterone inhibitors and exercise self-care behaviors. Aldosterone inhibitors are used as a diuretic in HF (Butler et al., 2012). Although aldosterone inhibitors have benefits in reducing cardiovascular death, all-cause mortality, and hospitalization in HF patients with reduced ejection fraction, its use is often associated with occurrence of hyperkalemia (Butler et al., 2012).Muscle weakness, feelings of numbness/tingling, nausea/vomiting and other serious side effects can occur with hyperkalemia. A previous study demonstrated a reduction in the six-minute walk distance among HF patients prescribed aldosterone inhibitors (Edelmann et al., 2013). This indicates that aldosterone inhibitors have the potential to limit exercise capacity in some persons with T2D-HF. This has important clinical implications to monitor for hyperkalemia including avoiding other potassium sparing drugs and foods containing high amount of potassium, and continuous laboratory monitoring of blood potassium level. The effects of aldosterone inhibitors are influenced by race with African American's more often experiencing hypokalemia (Vardeny et al., 2013). It is also plausible that treatment differences between African Americans and Whites may have contributed to exercise adherence, although the underlying mechanisms are unclear (Taylor et al., 2007). Persons with T2D-HF have been shown to have a lower six-minute walk test distance than those without HF (Ingle, Reddy, Clark, & Cleland, 2006). The six-minute walk test is safe, easy to administer, well-tolerated in a variety of chronic conditions and when routinely measured, may provide valuable clinical information about functional capacity and identify declining physical function earlier when it still may be amenable to intervention.

Dyslipidemia was associated with poor adherence to foot care increasing the risk for foot ulcers and amputations. A previous study also reported that dyslipidemia was significantly correlated with a higher incidence of amputation among persons with diabetic foot ulcers (Zubair, Malik, & Ahmad, 2012). In this study, dyslipidemia may have served as a proxy for older age, underlying peripheral arterial disease and higher NYHA or more advanced CVD. Studies suggest that close monitoring and management of dyslipidemia with lipid lowering therapy reduces CVD morbidity and mortality and improves survival in diabetic patients with foot ulcers. Statins have been shown to decrease the progression of peripheral arterial disease, improving symptoms and reducing amputations (Yang et al., 2016). Because persons with T2D and HF often have dyslipidemia as a comorbid condition, it is important they are educated and made aware that adhering to the prescribed lipid lowering therapy reduces their risk for developing progressive peripheral arterial disease and other associated vascular complications.

Strength and limitations

Examining the correlates of diabetes self-care behaviors using an integrated framework in persons with T2D-HF was strength of this study. Findings from this study provide greater awareness of the need for integrated self-care interventions rather than the conventional disease specific approach. In addition, the sample characteristics included predominately African American men who have received less attention concerning the performance of T2D self-care behaviors. Findings from this study add to the literature concerning the demographic and clinical antecedents that influence T2D self-care behaviors in this population. Recruitment occurred at four urban academic tertiary healthcare centers which increased diversity of our sample.

There were also several limitations. Using forward stepwise logistic regression models, this study controlled for covariates to reduce the threat of bias, but there may be threats we are unaware that confounded study findings. As with any secondary analysis, the present study is limited by the scope of data and instruments used in the parent study. Because our population was predominately African American men, the findings may not be generalizable to Whites and women with comorbid T2D-HF.

Conclusion

The research related to diabetes self-care behaviors has been disease-specific with little attention given to the influence that other comorbid chronic illnesses may have on T2D self-care behaviors. Accounting for other comorbid conditions in diabetes self-care research may lead to more effective interventions (Dunbar et al., 2014).Using an integrated self-care framework we have identified several predictors of diabetes self-care behaviors (SMBG, foot care, and exercise) in persons with T2D-HF. The findings of this study suggest that clinicians be aware of other comorbid conditions and treatment regimens that may complicate clinical care. Given the expected rise of T2D-HF in the foreseen future, increased research on self-care interventions that incorporate an integrated approach will be vital for improving clinical outcomes in the management of complex and coexisting chronic conditions.

CHAPTER IV

Article 3: Correlates of Diabetes Self-Care Behaviors and Glycemic Control in Adults with Type 2 Diabetes and Comorbid Heart Failure

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Abstract

Background: Effective diabetes self-care behavior is essential for improving glycemic control in persons with type 2 diabetes (T2D). Other chronic conditions such as heart failure (HF) are more common in persons with T2D which also requires complex treatment regimens that may compete with effective diabetes self-care. Little is known, however, about the relationships between performance of diabetes self-care behaviors and glycemic control in persons with T2D and comorbid HF.

Objective: The purpose of this study was to describe the relationship between diabetes self-care behaviors and glycemic control (HbA1c and FBG) in T2D patients with comorbid HF.

Method: Baseline data from a randomized clinical trial that tested a 6-month integrated self-care intervention in 180 adults with T2Dand comorbid HF was analyzed. Demographic, clinical, and psychosocial data were collected from medical records and self-report. Diabetes self-care behaviors were measured using the Summary of Diabetes Self-Care Activities (SDSCA).Glycated hemoglobin (HbA1c) and fasting blood glucose (FBG) were analyzed from whole blood samples at baseline. Correlational and hierarchical linear regression analysis was used to assess the association between diabetes self-care behaviors and glycemic control.

Result: Participants had a mean age of 58±11 years, T2D duration of 11±8 years and HF duration of 5.3±5.9 years, and the majority were male (n = 118, 65.6%) and African American (n = 119, 66.1%).In a bivariate analysis, the SDSCA general diet ($p = 0.036$) and SDSCA exercise ($p = 0.029$) were negatively associated with HbA1c, while SDSCA specific diet ($p = 0.047$) was positively associated. None of the diabetes self-care behaviors emerged as independent predictors of either HbA1c or FBG in the regression models. Diabetic-end organ failure, taking insulin only, taking oral antiglycemic and insulin, African American race, and dyslipidemia predicted higher HbA1c values ($p < 0.05$). Years since diagnosis of HF ($p < 0.05$), taking insulin ($p < 0.01$), diabetic-end organ failure ($p < 0.01$), and total daily medications ($p < 0.05$) predicted higher FBG values.

Conclusion: Findings from this study suggests that persons with a higher number of chronic conditions may experience greater disease burden which negatively influences their ability to perform effective diabetes self-care and achieve glycemic control. Future research is warranted to determine how to best design self-care interventions for persons with multiple comorbid conditions in order to improve health outcomes and quality of life.

Keywords: type 2 diabetes, heart failure, diabetes self-care, glycemic control, nursing

Introduction

Type 2 diabetes mellitus (T2D) is a leading cause of morbidity and mortality worldwide (Zimmet & Alberti, 2016). With the contribution of population growth and ageing, the number of adults with diabetes mellitus (DM), has almost quadrupled during the past two decades (NCD Risk Factor Collaboration (NCD-RisC, 2016)). The International Diabetes Federation's (IDF) projection indicates that the prevalence of DM in adults (20-79 years) will rise from 425 million (8.8%) in 2017 to 629 million (9.9%) in 2045 (IDF, 2017). Of this number, over 90% are persons with T2D (Holman et al., 2015; G. Xu et al., 2018). In the United States, T2D is currently the seventh-leading cause of death (CDC, 2017).

Individuals with T2D have increased risk for developing cardiovascular disease (CVD) including myocardial infarction, heart failure, and stroke (Peneni & Luscher, 2017). Heart failure (HF) was reported as the most common initial manifestation of CVD followed by peripheral arterial disease (Shah et al., 2015). In people with T2D worldwide, the prevalence of HF is 14.9% (Einarson et al., 2018) which is higher than the 1-12% in the general population(Roger, 2013). Individuals with T2D and comorbid HF have increased physical limitations, poorer survival rates and quality of life (Bauduceau et al., 2018).

Hyperglycemia is an important risk factor for CVD events and all-cause mortality in people with T2D (Afsharian et al., 2016; Takao, Suka, Yangisawa, & Iwamoto, 2017). Evidence concerning the effect of intensive glycemic control using antidiabetic agents on preventing adverse CVD events in T2D are inconclusive (Abdul-Ghani et al., 2017). Participation in effective diabetes self-care behaviors and lifestyle modifications such as increasing physical activity, healthy dietary patterns and not smoking have been shown to be effective for the reduction of CVD risk in this population (Long, Cooper, Wareham, Griffin, & Simmons, 2014; Rautio et al., 2015; Wong et al., 2015).

Diabetes self-care behaviors are important for the improvement of glycemic control in T2D. Diabetes self-care behaviors are characterized as the development of expertise that includes transitioning from a passive recipient of care to active participation in disease management (B. Paterson & S. Thorne, 2000). Studies have consistently demonstrated that adherence to the recommended diabetes self-care behaviors is associated with better glycemic control in T2D (Al-Khawaldeh, Al-Hassan, & Froelicher, 2012; Captieux et al., 2018; Kamuhabwa & Charles, 2014; Khattab, Khader, Al-Khawaldeh, & Ajlouni, 2010; A. A. Lee, Piette, Heisler, Janevic, & Rosland, 2019; Zheng et al., 2019). A meta-analysis of the effect of diabetes self-care interventions identified reduction of glycated hemoglobin (HbA1c) between 0.2 - 0.6% at 6 months post-intervention in people with T2D (Captieux et al., 2018). A recently published randomized controlled trial of an outpatient diabetes self-care program for people with T2D reported that the intervention significantly improved fasting blood glucose, postprandial blood glucose and HbA1c (Zheng et al., 2019).

Demographic, clinical, and psychosocial variables may also influence glycemic control. Studies have shown that female gender, advancing age, using more than one antiglycemic agent, lack of health insurance and obesity (Kamuhabwa & Charles, 2014), duration of DM (Kamuhabwa & Charles, 2014; Khattab et al., 2010), and negative attitude towards DM (Khattab et al., 2010) were associated with poor glycemic control in people with T2D. Higher diabetes self-efficacy, social support (Shao, Liang, Shi, Wan, & Yu, 2017) and satisfaction with diabetes treatment (Moreira et al., 2010) are associated with better glycemic control in T2D.

Conceptual framework

This study adapted an integrated conceptual framework originally designed to guide a self-care intervention in HF (Dunbar et al., 2008) (Figure 1). The framework incorporates concepts from self-management theories and adult learning concepts used in patient education. The variables in the conceptual framework are organized around antecedents and outcomes of self-care behaviors. In the current study, an individual's demographic, clinical, and psychosocial characteristics were considered as antecedents to diabetes self-care behaviors. The clinical characteristics involve variables depicting duration and severity of both T2D and HF while the

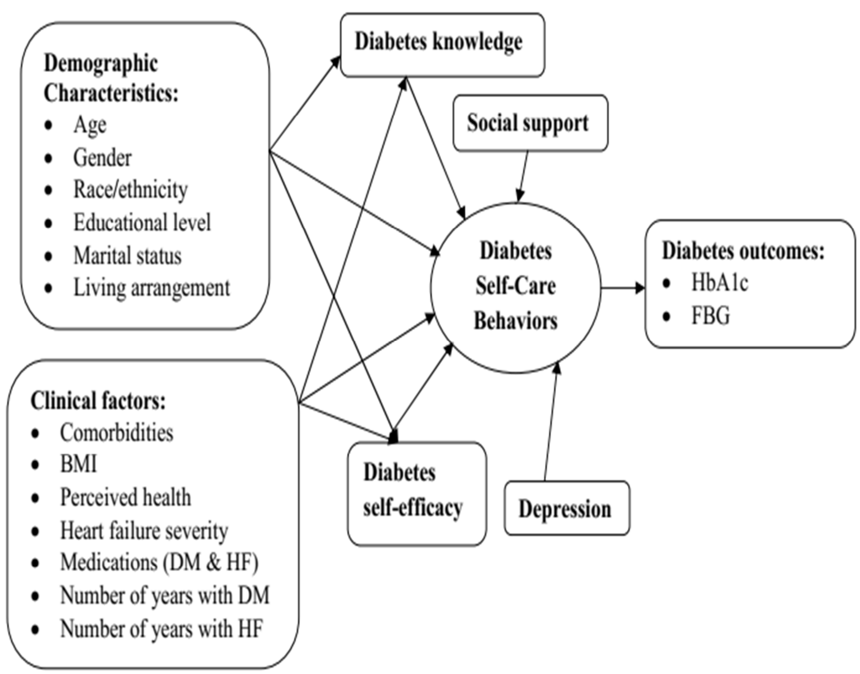

Figure 4-0-1 The conceptual model for diabetes self-care behaviors in adults with type 2 diabetes mellitus and comorbid heart failure. The model was adapted from the integrated conceptual framework for heart failure self-care research (Dunbar et al.2008)

psychosocial variables are diabetes self-efficacy, social support, depression and diabetes knowledge. The diabetes self-care outcome in this study was glycemic control indicated by HbA1c and fasting blood glucose (FBG) values. To date, most studies that have assessed the relationship between diabetes self-care behaviors and glycemic control did not take into account the presence of another serious chronic illness such as HF.As a result, there is little research on how HF may influence diabetes self-care behaviors and glycemic control in T2D. Because T2D and HF often are coexisting chronic conditions, a greater understanding of factors that may influence diabetes self-care behaviors are essential for designing effective interventions that can improve glycemic control and to prevent the occurrence of adverse events.

Methods

Purpose

The purpose of this study was to describe the relationship between diabetes self-care behaviors and glycemic control (HbA1c and FBG) in T2D adult patients with comorbid HF. The hypothesis tested was that among T2D adult patients with comorbid HF, greater diabetes self-care behavior would be associated with better glycemic control controlling for demographic, clinical, and psychosocial variables.

Study design

This study used a cross-sectional, correlational design to analyze baseline data from a randomized clinical trial that tested a 6-month integrated self-care intervention in adult patients withT2D and comorbid HF.

Participants and data collection

The parent study enrolled adult patients with comorbid HF and T2D during hospitalization or within 3 months of discharge for worsening HF. Participants' enrollment was performed at 1 of 4 large urban-tertiary hospitals in the southeastern part of the United States from 2010 to 2013. Participants who were aged 21-80 years, with New York Heart Association Class II-IV and were either currently hospitalized or recently discharged within the last 3-months were enrolled in the study. Other inclusion criteria included the presence of T2D, ambulatory and eligible for physical activity, prescribed optimal HF medications according to guidelines and eligible for low sodium and carbohydrate diets. The exclusion criteria were new diagnosis or first HF admission; cognitive impairment score of 11 or above on the Blessed Cognitive Screening Tool (BCST); uncorrected hearing or vision problem; undergoing evaluation for cardiac transplant or evaluation for ventricular assist device; renal failure; lack of telephone access; and severe chronic pulmonary disease and previous stroke impeding ambulation and ability to exercise. The study was approved by the local Institutional Review Board (IRB) and all participating institutions. All participants provided written informed consent prior to baseline measures.

The sample size was computed using Green's recommendation for the determination of sample size for multiple regression analysis (Green, 1991). A total of 180 participants' baseline data were included in this study. The effect size (f^2) for this sample size is 0.044, which is small to medium and satisfied the requirement for a power of 0.80 based on Cohen's recommendation at statistical significance level of 0.05 (Cohen, 1988).

Measurement

Demographic and clinical information

Demographic and clinical data were collected from medical records and self-report. The variables included age, gender, race/ethnicity, marital status, education, body mass index (BMI), perceived health rating, living arrangement, NYHA functional classification, years since diagnosis of T2D and HF, left ventricular ejection fraction (LVEF), diabetes with end organ failure, diabetes management regimen/type, medications. The number of comorbid chronic conditions was documented using the Charlson comorbidity index (Charlson et al., 1987; Charlson et al., 1994).

Diabetes self-care behaviors

The Summary of Diabetes Self-Care Activities (SDSCA) was used to measure the self-care behaviors of the study participants (Toobert et al., 2000). The SDSCA has a core set of 11 items used to measure the diabetes self-care behaviors of diet, exercise, blood glucose testing, foot care, and smoking. Participants reported how many days in the previous week they have engaged in a particular self-care activity and scores were calculated for each dimension. The total score range 0 – 28 for diet, 0 – 14 for exercise, 0 – 14 for self-monitoring blood glucose and 0 – 14 for foot care (Toobert et al., 2000). A study reported Cronbach's alpha of 0.76 for the overall scale and 0.89 for diet, 0.83 for exercise, 0.92 for blood glucose testing, and 0.77 for foot care dimensions (Aljohani et al., 2016).

Glycemic control

Glycated hemoglobin (HbA1c) and fasting blood glucose (FBG) were used to measure glycemic control. Both biomarkers were analyzed from whole blood samples at baseline. HbA1c is the gold standard for monitoring glycemic control and reflects a person's glucose control for the preceding 8 – 10 weeks (ADA, 2019c). FBG provides immediate blood ranges to guide treatment, food and activity choices (Krhac & Lovrencic, 2019). The American Diabetes

Association (ADA, 2019c)recommends a glycemic goal of HbA1c <7% (53 mmol/mol) which equivalent to FBG 80 – 130 mg/dL (4.4 – 7.2 mmol/L) in persons with T2D. Analysis was conducted in the clinical laboratory using high performance liquid chromatography, with standardization through commercially available controls (CV <2%). FBG test was also performed at the clinical laboratory after 8-hours of fasting.

Diabetes self-efficacy

Diabetes self-efficacy was measured using the 8-item Perceived Diabetes Self-Management Scale (PDSMS). The scale was developed by Wallston and colleagues (Wallston et al., 2007) and has responses for each item ranging from 1 (strongly disagree) to 5 (strongly agree) with the total score ranging from 8 to 40. A higher score shows more confidence in performing diabetes self-care behaviors. The PDSMS has adequate reported reliability with Cronbach's alpha's between 0.83 and 0.93 (Al-Aboud et al., 2016).

Diabetes knowledge

The Michigan Diabetes Knowledge Test (DMKT) was used to measure the participants' knowledge of diabetes (Fitzgerald et al., 2016). The tool was scored based on the percent of questions answered correctly. The DMKT consists of 14-item and has adequate reported reliability with a Cronbach's alpha of 0.77 (Fitzgerald et al., 2016).

Depression

The Patient Health Questionnaire-9 (PHQ-9) is a widely used depression screening instrument and has been used in T2D and in HF populations(Kroenke et al., 2001). The 9-item depression scale includes ratings of symptoms as 0 (indicating not at all) to 3 (nearly every day). Scores range from 0 to 27, with a score of 5 – 9 reflecting mild depressive symptoms to ≥10 indicating moderate to severe depressive symptoms. The PHQ-9 has adequate internal reliability with a Cronbach's alpha of 0.89 (Yaung et al., 2008).

Social support

The ENRICHD Social Support Instrument (ESSI) was used to assess the social support available to the participants (ENRICHD, 2000). The instrument is a 7-item self-report survey that assesses perceived social support and has been used with a number of studies. All items values are summed for a total score, with higher score denoting greater social support. The ESSI in the original study has demonstrated acceptable internal consistency with a Cronbach's alpha of 0.86 to 0.88 (Vaglio et al., 2004).

Data analysis

Prior to analysis, the data were examined for accuracy, completeness, potential outliers, and missing values. The distributions of outcome variables (HbA1c and FBG) were scrutinized for normality by visual inspection and the Shapro-Wilk and Kolmogorov-Smirnov tests. The normality assessment revealed skewness in the distribution of these outcome data. This problem was resolved using square root and base 10 log transformation methods. The HbA1c data that had moderately positive skewness was square root transformed while the FBG data that had substantial positive skewness was base 10 log transformed (Tabachnick & Fidell, 2007). Bivariate analysis using correlation coefficients (Pearson *r* and Spearman's *rho*), independent-sample t-test, and one-way analysis of variance (ANOVA) were conducted to assess the demographic, clinical, psychosocial variables, and diabetes self-care behaviors relationships with HbA1c and FBG. Pearson *r* was used when the two variables in the correlation analysis were normally distributed and Spearman's *rho* was used when the assumption of normality violated by at least one variable in the analysis and when this problem could not be fixed using data transformation method. Statistical significance was set at 5%. Hierarchical multiple regressions were used to assess whether greater diabetes self-care behaviors were associated with better glycemic control (lower glycated hemoglobin [HbA1c] and fasting blood glucose [FBG]) after controlling for demographic, clinical and psychosocial variables. Multi-categorical independent variables were dummy coded before entering into the models. To avoid the issues of multicollinearity, inter-correlations between variables were examined but no inter-correlation higher than 0.80 was found. Moreover, the Durbin-Watson test was used to assess the independence of residuals (value of 2 for complete independence). Magnitude of difference and effect sizes were also computed for each variable. The data were analyzed using SPSS for Windows version 24 (IBM SPSS Statistics 24).

Result

Participant characteristics

The mean age of the study participants was 58±10.7 years (Table 1), the majority were male (n= 118, 66%) and African American (n= 119, 66%). Most had more than a high school education (n = 114, 63.3%) and lived with a spouse or children (n = 116, 64.4%).The mean number of years since diagnosis of T2D was 11±8.4 and 5±5.9 for HF (Table 2). Clinically, the mean left ventricular ejection fraction (LVEF) was 34 ± 16.9; the number of medications taken was 12±3.9 and most had an average of 4±2.3 chronic conditions (Table 3). Before data transformation, the mean HbA1c was 8±1.8% and the mean FBG was 165±79.4 mg/dl (Table 2). The mean score of general dietary self-care behavior was 5±1.9 and diabetes-specific dietary self-care behavior was 5±1.5 per week (Table 1). The majority of the participants (n = 109, 67%) performed foot care less than 7 days per week while 86 (48%) undertook blood glucose testing for less than 7 days per week and 66 (37%) did not exercise a minimum one day per week. The mean depression score was 7±4.4.

Demographic, psychosocial, and diabetes self-care behaviors on glycemic control

The bivariate analysis (Table 1) showed significant negative correlations between HbA1c and age (r = -0.17, p = 0.03), diabetes self-efficacy (r = -0.231, p = 0.005), and general dietary self-care behavior (r = -0.171, p = 0.036). An increase in age, diabetes self-efficacy, and general dietary self-care behavior were associated with a decrease in HbA1c. Specific dietary self-care behavior had a significant positive correlation with HbA1c (r = 0.162, p = 0.047). The independent-sample t-test revealed that participants who did not exercise for a minimum of 1 day per week compared to those who exercised 1 day or more per week had a significantly higher HbA1c value, t (150) = 2.208, p = 0.029 (Mean difference [MD] = 0.11, 95%CI: 0.011, 0.22).

Table 4-0-1 Demographic characteristics, psychosocial factors, and self-care behaviors of comorbid T2D-HF patients on glycemic control (N = 180)

Characteristics	Overall n (%)	Glycated hemoglobin (HbA1c)*(Square root transformed)*		Fasting blood glucose*(Log10 transformed)*	
		Mean±SD	Test of Association	Mean±SD	Test of Association
Demographic:					
Age, y, mean±SD	58.1±10.7	2.8±0.3	*r* = -0.17, *p* = 0.03	2.2±0.2	*r* = -0.129, *p* = 0.094
Sex:					
Female	62 (34.4%)	2.9±0.3	*t* = 0.599, *p* = 0.551	2.1±0.2	*t* = -0.470, *p* = 0.639
Male	118 (65.6%)	2.8±0.3		2.2±0.2	
Race:					
None-AA (white or Asian)	61 (33.9%)	2.8±0.2	*t* = 0.277, *p* = 0.782	2.2±0.2	*t* = 0.474, *p* = 0.636
African American (AA)	119 (66.1%)	2.8±0.3		2.2±0.2	
Marital status:					
Single/divorced/widowed	90 (50%)	2.8±0.3	*t* = 0.035, *p* = 0.973	2.2±0.2	*t* = 0.303, *p* = 0.762
Married/domestic partner	90 (50%)	2.8±.3		2.2±0.2	
Education:					
≤ High school	65 (36.1%)	2.9±0.3	*t* = 0.945, *p* = 0.347	2.2±0.2	*t* = 0.596, *p* = 0.552
> High school	114 (63.3%)	2.8±0.3		2.2±0.2	
Perceived health rating:					
Poor	53 (29.4%)	2.8±0.3	1-ANOVA = *F* (2, 148)	2.1±0.2	1-ANOVA = *F* 92, 161)
Fair	73 (40.6%)	2.9±0.3	= 0.882, *p* = 0.416	2.2±0.2	= 0.803, *p* = 0.450
Good	49 (27.2%)	2.8±0.3		2.2±0.2	
BMI, kg/m2, mean±SD	36.7±8.9	2.8±0.3	*rho* = 0.115, *p* = 0.153	2.2±0.2	*rho* = 0.127, *p* = 0.099
Living arrangement:					
Live alone	41 (22.8%)	2.8±0.3	1-ANOVA = *F* (2, 153)	2.2±0.2	1-ANOVA = *F* (2, 166)
Live with spouse/children	116 (64.4%)	2.8±0.3	= 0.241, *p* = 0.786	2.2±0.2	= 0.372, *p* = 0.690
Live with siblings/other relatives	23 (12.8%)	2.8±0.2		2.1±0.2	
Psychosocial factors:					
Depression, mean±SD	6.7±4.4	2.8±0.3	*rho* = -0.004, *p* = 0.960	2.1±0.2	*rho* = 0.020, *p* = 0.798
Social support, mean±SD	27.9±5.8	2.8±0.3	*rho* = 0.020, *p* = 0.841	2.2±0.2	*rho* = -0.063, *p* = 0.509
Self-efficacy, mean±SD	27.7±6.2	2.8±0.3	*r* = -0.231, *p* = 0.005	2.2±0.2	*r* = -0.136, *p* = 0.084
Diabetes knowledge, mean±SD	57.9±18.2	2.8±0.3	*r* = 0.024, *p* = 0.763	2.2±0.2	*r* = 0.057, *p* = 0.463
Diabetes self-care behaviors:					
General diet, mean±SD	5.1±1.9	2.8±0.3	*r* = -0.171, *p* = 0.036	2.2±0.2	*r* = -0.068, *p* = 0.392
Specific diet. mean±SD	4.6±1.5	2.8±0.3	*r* = 0.162, *p* = 0.047	2.2±0.2	*r* = -0.095, *p* = 0.223
Exercise;					
= 0 days per week	66 (36.7%)	2.8±0.3	*t* = 2.208, *p* = 0.029	2.2±0.2	*t* = 0.400, *p* = 0.690
> 0 days per week	109 (60.6%)	2.8±0.3		2.2±0.2	
Blood glucose testing:					
< 7 days per week	86 (47.8%)	2.8±0.4	*t* = -0.045, *p* = 0.579	2.2±0.2	*t* = 1.565, *p* = 0.120
= 7 days per week	88 (48.9%	2.8±0.2		2.1±0.2	
Foot care:					
< 7 days per week	109 (60.6%)	2.8±0.3	*t* = 0.895, *p* = 0.373	2.2±0.2	*t* = 0.654, *p* = 0.514
= 7 days per week	66 (36.7%)	2.9±0.3		2.1±0.2	

r = Pearson's correlation coefficient; t = Independent-sample t-test; rho = Spearman's correlation coefficient; 1-ANOVA = One way analysis of variance.

Clinical characteristics on glycemic control

An independent-sample t-test (Table 2) revealed that participants who were managed with diet plus medication compared to those who managed with diet alone had significant lower HbA1c values, t (153) = -5.694, p< 0.001 (MD = -0.32, 95%CI: -0.44, -0.20). Similarly, participants who were using insulin compared to those who were not using insulin had significantly lower HbA1c values, t (154) = -6.297, p < 0.001 (MD = -0.27, 95CI: -0.35, -0.19).

A one-way between groups ANOVA was conducted to explore the impact of medication categories on HbA1c level (Table 2). Participants were divided into four diabetes medication categories: oral diabetes medication only, insulin only, both oral diabetes medication and insulin, and no to both. There was a significant difference ($p < 0.05$) level in HbA1c values for the four diabetes medication categories, F (3, 152) = 16.250, $p < 0.001$. The difference in mean scores of HbA1c between the diabetes medication categories was quite large with a partial eta square (effect size) of 0.24. Post hoc comparison using Sidak test indicated there were significantly higher HbA1c values among participants who were not taking both oral diabetes medication and insulin compared to those who were taking oral diabetes medication only (MD = 0.26, 95%CI: 0.04, 0.46), taking insulin only (MD = 0.46, 95%CI: 0.26, 0.65), and taking both oral diabetes medication and insulin (MD = 0.45, 95CI: 0.20, 0.69).

Correlation analysis (Table 2) showed significant inverse relationships between years since diagnosis of HF and FBG level (*rho* = -0.202, p = 0.009). As the number of years since HF diagnosis increased the person's FBG level decreased. An independent-sample t-test revealed that participants who were using insulin compared to those who were not using insulin had statistically significant lower FBG level, t (167) = -3.214, $p = 0.002$ (MD = -0.10, 95%CI: -0.15, -0.03). A one-way between groups ANOVA also identified that there was significant difference ($p < 0.05$) in FBG values for the four diabetes medication categories, F (3, 165) = 3.744, p = 0.012. The actual difference in mean scores of FBG between the diabetes medication categories was medium with a partial eta square of 0.06. Post hoc comparison using Sidak test indicated that there were statistically significant higher FBG values among participants who were not taking both oral diabetes medication and insulin compared to those who taking insulin only (MD = 0.17, 95%CI: 0.02, 0.31).

Table 4-0-2 Clinical characteristics of comorbid T2D-HF patients on glycemic control (N = 180)

Characteristics	Overall n (%)	Glycated hemoglobin (HbA1c)*(Square root transformed)*		Fasting blood glucose*(Log10 transformed)*	
		Mean±SD	Test of Association	Mean±SD	Test of Association
Glycated hemoglobin (HbA1c)	8.1±1.8%				
Fasting blood glucose (FBG)	165±79.4 mg/dL				
NYHA Functional class:					
Class I and II	70 (38.9%)	2.9±0.3	*t* = 1.525, *p* = 0.130	2.2±0.2	*t* = -0.032, *p* = 0.975
Class III and IV	109 (60.6%)	2.8±0.3		2.2±0.2	
HF duration, y, mean±SD	5.3±5.9	2.8±0.3	*rho* = -0.075, *p* = 0.362	2.2±0.2	*rho* = -0.202, *p* = 0.009
Ejection fraction, mean±SD	33.6±16.9	2.8±0.3	*rho* = 0.061, *p* = 0.452	2.2±0.2	*rho* = 0.062, *p* = 0.427
DM duration, y, mean±SD	11.1±8.4	2.8±0.3	*rho* = 0.076, *p* = 0.345	2.2±0.2	*rho* = 0.046, *p* = 0.558
DM with end organ failure:					
No	137 (76.1%	2.8±0.3	*t* = -1.012, *p* = 0.315	2.1±0.2	*t* = -1.250, *p* = 0.216
Yes	42 (23.3%)	2.9±0.3		2.2±0.2	
DM management regimen:					
Diet alone	15 (8.3%)	2.5±0.2	*t* = -5.694, *p* = 0.000	2.1±0.2	*t* = -2.026, *p* = 0.059
Diet plus medications	163 (90.6%)	2.9±0.3		2.2±0.2	
ACE inhibitor use:					
No	81 (45.0%)	2.8±0.3	*t* = -1.577, *p* = 0.117	2.1±0.2	*t* = -1.351, *p* = 0.179
Yes	97 (53.9%)	2.8±0.3		2.2±0.2	
ARB use:					
No	146 (81.1%	2.8±0.3	*t* = 1.302, *p* = 0.201	2.2±02	*t* = -0.443, *p* = 0.662
Yes	25 (13.9%)	2.8±0.2		2.2±0.2	
Beta blockers use:					
No	11 (6.1%)	2.9±0.3	*t* = 0.360, *p* = 0.728	2.2±0.3	*t* = -0.099, *p* = 0.923
Yes	167 (92.8%)	2.8±0.3		2.2±0.2	
Diuretics use:					
No	127 (70.6%)	2.8±0.3	*t* = -0.791, *p* = 0.432	2.1±0.2	*t* = -1.716, *p* = 0.091
Yes	45 (25.0%)	2.9±0.3		2.2±0.2	
Loop diuretics use:					
No	21 (11.7%)	2.9±0.4	*t* = 0.413, *p* = 0.684	2.1±02	*t* = -0.758, *p* = 0.456
Yes	158 (87.8%)	2.8±0.3		2.2±0.2	
Aldosterone inhibitors use:					
No	113 (62.8%)	2.8±0.3	*t* = -0.656, *p* = 0.514	2.2±0.2	*t* = 1.175, *p* = 0.243
Yes	49 (27.2%)	2.9±0.3		2.1±0.2	
Digitalis use:					
No	156 (86.7%)	2.8±0.3	*t* = 0.423, *p* = 0.677	2.2±0.2	*t* = 1.996, *p* = 0.058
Yes	20 (11.1%)	2.8±0.3		2.1±0.2	
Total daily medication, mean ±SD	12.2 (3.9)	2.8±0.3	*rho* = -0.103, *p* = 0.200	2.2±0.2	*rho* = 0.009, *p* = 0.906
Oral DM medication use:					
No, unknown or missing	114 (63.3%)	2.9±0.3	*t* = 1.372, *p* = 0.172	2.2±0.2	*t* = 0.823, *p* = 0.412
Yes	66 (36.7%)	2.8±0.2		2.1±0.2	
Insulin use:					
No, unknown or missing	66 (36.7%)	2.7±0.2	*t* = -6.297, *p* = 0.000	2.1±0.2	*t* = -3.214, *p* = 0.002
Yes	114 (63.3%)	2.9±0.3		2.2±0.2	
DM medication category:					
Oral medication only	48 (26.7%)	2.7±0.2	1-ANOVA = *F* (3, 152) = 16.250, *p* = 0.000; ***SDP***: No to both Vs Oral med only* , No to both Vs Insulin only**, No to both Vs Yes to both***	2.1±0.2	1-ANOVA = *F* (3, 165) = 3.744, *p* = 0.012; ***SDP:*** No to both Insulin only: MD = 0.17, *p* = 0.015
Insulin only	96 (53.3%)	2.9±0.3		2.2±0.2	
Both oral and insulin	18 (10.0%)	2.9±0.2		2.2±0.2	
No to both	18 (10.0%)	2.5±0.2		2.0±0.1	

t = Independent-sample t-test; rho = Spearman's correlation coefficient; 1-ANOVA = One way analysis of variance; ***SDP*** = Sidak post hoc test; *Mean difference (MD) = 0.26 (*p* = 0.007); **MD = 0.46 (*p*< 0.001); ***MD = 0.45 (*p*< 0.001).

Multi-morbidity and glycemic control

The independent-sample t-test (Table 3) revealed that participants having more than 2 comorbid conditions (Charlson comorbidity > 2) compared to those with only 2 comorbid conditions (T2D and HF only) had a significantly higher HbA1c level (Table 3), t (154) = 2.657, p = 0.01. There were several disease specific conditions that influenced HbA1c values. Participants who had arthritis compared to those without arthritis had higher HbA1c values, t (152) = 2.923, p = 0.004 (MD = 0.13, 95%CI: 0.04, 0.22). Compared to participants with a history of valve repair to those without history of valve repair had statistically significant higher FBG level, t (165) = 4.480, p = 0.001 (MD = 0.13, 95%CI: 0.06, 0.19).

Table 4-0-3 Multimorbid conditions on glycemic control of comorbid T2D-HF patients (N = 180)

Characteristics	Overall n (%)	Glycated hemoglobin (HbA1c)*(Square root transformed)*		Fasting blood glucose *(Log10 transformed)*	
		Mean±SD	**Test of Association**	**Mean±SD**	**Test of Association**
CCI, mean±SD	4.2±2.3	2.8±0.3	*rho* = -0.091, *p* = 0.256	2.2±0.2	*rho* = -0.029, *p* = 0.704
Charlson comorbidity > 2:					
No	47 (26.1%)	2.9±0.3	*t* = 2.657, *p* = 0.010	2.2±0.2	*t* = 0.850, *p* = 0.398
Yes	133 (73.9%)	2.8±0.3		2.2±0.2	
Depression history					
No	136 (75.6%)	2.8±0.3	*t* = 0.545, *p* = 0.588	2.2±0.2	*t* = -0.963, *p* = 0.340
Yes	41 (22.8%)	2.8±0.3		2.2±0.2	
Hypertension:					
No	9 (5.0%)	2.9±0.3	*t* = 0.292, *p* = 0.777	2.2±0.1	*t* = 1.614, *p* = 0.142
Yes	170 (94.4%)	2.8±0.3		2.2±0.2	
Arthritis:					
No	135 (75.0%)	2.9±0.3	*t* = 2.923, *p* = 0.004	2.2±02	*t* = 1.055, *p* = 0.295
Yes	43 (23.9%)	2.7±0.2		2.1±0.2	
CABG:					
No	142 (78.9%)	2.8±0.3	*t* = 331, *p* = 0.742	2.2±0.2	*t* = 0.005, *p* = 0.996
Yes	38 (21.1%)	2.8±0.3		2.2±0.2	
History of valve repair:					
No	170 (94.4%)	2.8±0.3	*t* = 1.959, *p* = 0.084	2.2±0.2	*t* = 4.480, *p* = 0.001
Yes	8 (4.4%)	2.7±0.2		2.0±0.1	
History of valve replacement:					
No	171 (95.0%)	2.8±0.3	*t* = 0.394, *p* = 0.705	2.2±0.2	*t* = 0.361, *p* = 0.726
Yes	8 (4.4%)	2.8±0.3		2.1±0.1	
History of PTCA or PCI:					
No	128 (71.1%)	2.8±0.3	*t* = 0.123, *p* = 0.902	2.2±0.2	*t* = 1.495, *p* = 0.138
Yes	50 (27.8%)	2.8±0.2		2.1±0.2	
History of stent:					
No	140 (77.8%)	2.8±0.3	*t* = -0.386, *p* = 0.700	2.2±0.2	*t* = -0.579, *p* = 0.565
Yes	39 (21.7%)	2.8±0.2		2.2±0.2	
Dyslipidemia:					
No	83 (46.1%)	2.8±0.3	*t* = 0.957, *p* = 0.341	2.1±0.2	*t* = -0.559, *p* = 0.577
Yes	94 (52.2%)	2.8±0.2		2.2±0.2	
Sleep apnea:					
No	115 (63.9%)	2.8±0.3	*t* = 0.432, *p* = 0.666	2.2±0.2	*t* = 0.488, *p* = 0.626
Yes	64 (36.6%)	2.8±0.3		2.2±0.2	
Thyroid disorder:					
No	158 (87.8%)	2.8±0.3	*t* = 0.509, *p* = 0.615	2.2±0.2	*t* = 1.750, *p* = 0.093
Yes	21 (11.7%)	2.8±0.3		2.1±0.2	
Exposure to chemotherapy:					
No	172 (96.6%)	2.8±0.3	*t* = -0.571, *p* = 0.591	2.2±0.2	*t* = 0.874, *p* = 0.427
Yes	5 (2.8%)	2-9±0.1		2.1±0.2	
Pacemaker or devise:					
No	152 (84.4%)	2.8±0.3	*t* = 0.111, *p* = 0.912	2.2±0.2	*t* = -1.129, *p* = 0.269
Yes	27 (15.0%)	2.8±0.3		2.2±0.2	
ICD:					
No	105 (58.3%)	2.9±0.3	*t* = 1.280, *p* = 0.203	2.2±0.2	*t* = -0.159, *p* = 0.874
Yes	72 (40.0%)	2.8±0.3		2.2±0.2	

CCI = Charlson Comorbidity Index; rho = Spearman's correlation coefficient; t = Independent-sample t-test.

Predictors of glycemic control

Hierarchical linear regression analysis was used to assess whether greater diabetes self-care behaviors were associated with better glycemic control (HbA1c and FBG) after controlling for demographic, clinical and psychosocial variables. Demographic variables were entered at Step 1 (Model 1), clinical variables added at Step 2, Charlson comorbidity index scores were added at Step 3, psychosocial variables added at Step 4, and diabetes self-care behaviors added at Step 5.None of the specific diabetes self-care behaviors emerged as a predictor of HbA1c or FBG (Table 4 and 5).

As presented in Table 4, none of the variables entered in Model 1 were significant predictors of HbA1c. However, T2D with end organ failure and the two diabetes medication categories (taking insulin only and taking both oral diabetes medications and insulin) emerged as significant predictors of HbA1c in Model 2 (Table 4). Model 2 explained 51.6% of the variance in HbA1c, F (28, 56) = 2.131, p = 0.008. In Model 3, African American race and dyslipidemia emerged significant predictors of HbA1c and these remained in Model 4 and 5. Model 3 explained 69.4% [F (44, 40) = 2.065, p = 0.011] and Model 4 explained 69.9% [F (48, 36) = 1.741, p = 0.043] of the variance in HbA1c. Model 5 also explained 74.5% of the variance in HbA1c but this model was not significant, F (53, 31) = 1.713, p = 0.055. In the final model (Model 5), all the five variables were statistically significant, with dyslipidemia having a higher beta value ($\beta = 0.481$, $p < 0.05$).

Table 4-0-4 Summary of hierarchical regression analysis for variables predicting HbA1c (N = 180)

Variable	Model 1			Model 2			Model 3			Model 4			Model 5		
	B	**SE B**	**β**	**B**	**SE B**	**β**	**B**	**SE B**	**β**	**B**	**SE B**	**β**	**B**	**SE B**	**β**
DM with end organ failure (Yes)				0.248	0.90	0.337**	0.292	0.125	0.397*	0.277	0.135	0.376*	0.304	0.138	0.413*
DM medication categories:															
Take insulin only				0.250	0.087	0.409**	0.247	0.096	0.404*	0.267	0.261	-0.427*	0.243	0.113	0.396*
Taking both oral med and insulin				0.391	0.134	0.393**	0.356	0.148	0.357*	0.367	0.158	0.369*	0.344	0165	0.345*
African American race							0.259	0.098	0.398*	0.242	0.105	0.372*	0.304	0.145	0.466*
Dyslipidemia							0.197	0.093	0.320*	0.214	0.101	0.348*	0.296	0.123	0.481*
R^2		0.106			0.516			0.694			0.699			0.745	
F for change in R^2		0.787			2.788**			1.460			0.138			1.133	

SE B = Standard error of B (unstandardized regression coefficient); *p< 0.05; **p< 0.01

As presented in Table 5, none of the variables entered in Model 1 were significant predictors of FBG. HF duration (years) and the two diabetes medication categories (taking insulin only and taking both oral diabetes medications and insulin) emerged as significant predictors of FBG in Model 2 (Table 5). Model 2 explained 43.5% of the variance in FBG, F (28, 64) = 1.762, p = 0.032. In Model 3, left ventricular ejection fraction (LVEF), diabetes with end organ failure, total daily medications, and exposure to chemotherapy emerged as significant predictors of FBG and these remained in Mode 4 and 5. Model 3 explained 65.7% [F (44, 48) = 2.087, p = 0.007], Model 4 explained 67.9% [F (48, 44) = 1.942, p = 0.014], and Model 5 explained 71% [F (53, 39) = 1.799, p = 0.029] of the variance in FBG. In final model (Model 5), only 4 predictor variables were statistically significant, with diabetes with end organ failure having a higher beta value (β = 0.523, p< 0.01).

The condition indexes are < 30 and the variance inflation factors (VIF) are < 5 which supports that multicollinearity was not an issue for the predictor variables in Table 4 and 5. The assumption of independence of residuals was consistent with a Durbin-Watson test value of < 2 for the regression models of HbA1c and FBG.

Table 4-5 Summary of hierarchical regression analysis for variables predicting FBG (N = 180)

Variable	Model 1			Model 2			Model 3			Mode 4			Model 5		
	B	**SE B**	**β**	**B**	**SE B**	**β**	**B**	**SE B**	**β**	**B**	**SE B**	**β**	**B**	**SE B**	**β**
HF duration (years)				-0.011	0.004	-0.284*	-0.017	0.004	-0.461***	-0.015	0.005	-0.416**	-0.0120	0.005	-0.319*
DM medication categories:															
Take insulin only				0.118	0.056	0.302*	0.160	0.061	0.410*	0.197	0.066	0.505**	0.198	0.069	0.508*
Take both oral med and insulin				0.161	0.088	0.245	0.234	0.092	0.357*	0.238	0.095	0.362*	0.193	0.101	0.294
LVEF							-0.004	0.002	-0.343*	-0.004	0.002	-0.360*	-0.003	0.002	-0.254
DM with end organ failure							0.218	0.077	0.453**	0.219	0.078	0.454**	0.252	0.082	0.523**
Total daily medications							0.016	0.007	0.301*	0.018	0.008	0.354*	0.019	0.008	0.268*
Exposure to chemotherapy							-0.274	0.135	-0.249*	-0.323	0.140	-0.294*	-0.192	0.161	-0.175
R^2		0.088			0.435			0.657			0.679			0.710	
F for change in R^2		0.712			2.315**			1.934*			0.775			0.817	

LVEF = Left ventricular ejection fraction; **p*< 0.05; ***p*< 0.01; ****p*< 0.001

Discussion

The relationships between diabetes self-care behaviors and glycemic control in persons with T2D and comorbid HF have not been previously reported. The major finding was that T2D-HF patients with greater adherence to the SDSCA general diet and exercise recommendations had better glycemic control, corroborating previous studies (Cavero-Redondo et al., 2018; Sainsbury et al., 2018). However, contrary to previous findings (Sainsbury et al., 2018), participants who adhered to the SDSCA specific diet had higher HbA1c levels. In addition, findings showed that persons with greater than 2 comorbidities had poorer glycemic control which suggests that greater disease burden negatively impacts an individual's ability to perform effective diabetes self-care behaviors. Likewise, participants were prescribed an average of 12 medications which may also have contributed to higher disease burden and poor diabetes self-care given the complexity of T2D and HF treatment regimens. An unexpected finding was that none of the diabetes self-care behaviors were predictors of HbA1c or FBG which rejected our hypothesis. These findings provide compelling evidence that clinicians need to shift away from the conventional disease-specific model of diabetes self-care to an integrative approach that addresses the complex needs of T2D and HF, medication burden, as well as other comorbidities.

The only demographic variable that predicted higher HbA1c was African American race which is consistent with other studies (Assari, Lankarani, Piette, & Aikens, 2017; Egede, Mueller, Echols, & Gebregziabher, 2010; Kirk et al., 2006). According to the Centers for Disease Control (CDC), approximately 15million men in the US have a diabetes diagnosis, with African American and Hispanic men having a higher prevalence than non-Hispanic White men (CDC, 2017). African Americans are also reported to have poorer clinical outcomes, more likely to develop complications such as retinopathy and nephropathy and are more likely to be hospitalized with diabetes-related events associated with T2D in addition to higher risk for mortality (Bell et al., 2010; Davis-Smith, 2007; Dodani & Fields, 2010; Gatwood et al., 2018). The reasons that African American men have poorer clinical outcomes is not well described(Wessells, 2010). Previous research suggests that higher HbA1c among African Americans with T2D may be associated with socioeconomic status, lack of insurance coverage and lower educational level and poorer self-care practices (Assari et al., 2017; Egede et al., 2010). Future studies examining culturally appropriate diabetes self-care interventions are warranted given the high morbidity and poor health outcomes especially among African American's men.

The clinical variables that predicted higher HbA1cweredyslipidemia, having diabetic-end organ failure, taking insulin medication only, and taking both oral medication and insulin which in part may be a proxy for greater T2D and HF disease severity. Dyslipidemia was an independent predictor of higher HbA1c which is supported in previous studies(Chandra & Shukla, 2016; Thambiah et al., 2016). Both dyslipidemia and HbA1c are important risk factors for the development of CVD and higher mortality(Cavero-Redondo, Peleteiro, Alvarez-Bueno, Rodriguez-Artalejo, & Martinez-Vizcaino, 2017; J. S. Lee et al., 2017). Studies suggest that close monitoring and management of dyslipidemia with lipid lowering therapy reduces CVD morbidity and mortality and improves survival (Scicali et al., 2018). Because persons with T2D and HF often have dyslipidemia as a comorbid condition, it is important they are educated and made aware that adhering to the prescribed lipid lowering therapy reduces their risk for developing progressive peripheral arterial disease and the associated vascular complications. Integrated management of hyperglycemia and dyslipidemia in person's with T2D and comorbid HF is an important strategy for reducing the risk for adverse CVD and peripheral arterial events and improved glycemic control (Eeg-Olofssaon et al., 2016; Hanefeld, Traylor, Gao, & Landgraf, 2017).

The association between the two DM medication categories (taking insulin only and taking both oral medication and insulin) and higher HbA1c and FBG in this study may be due to exacerbation of insulin resistance by the presence of comorbid HF in T2D. Greater T2D disease severity may also play a role poorer glycemic control. Insulin resistance is common in persons with HF and may have contributed to higher glycemic values (Doehner, Frenneaux, & Nker, 2014). One study reported that comorbid HF more than doubles the incidence of T2D due to insulin resistance (Guglin, Lynch, & Krischer, 2014). Impaired response to either endogenous or exogenous insulin is a characteristics of insulin resistance (Church & Haines, 2016). This supports the need to look for ways to improve insulin uptake in persons with T2D and comorbid HF. The recommendation to augment drug treatment with self-care interventions including reduction in caloric intake and increasing exercise could also be useful to improve insulin resistance and to achieve better glycemic control in this population (Aroor, Mandavia, & Sowers, 2012).

The present study showed that years since diagnosis of HF was negatively associated with FBG. The duration of HF is likely a proxy for HF severity in this study. Our findings indicate that patients with comorbid T2D and HF become more hypoglycemic as the severity of HF increases. A previous study has reported that low FBG and increased glucagon are robust predictors of adverse events primarily mortality in patients with advanced HF (Melenovsky et al., 2017). Close FBG monitoring may be a useful intervention for preventing hypoglycemia and the adverse events associated with it in this population.

The regression models in the present study revealed that T2D-HF patients with diabetes-related end organ failure predicted poor control of bothHbA1c and FBG. Previous studies have shown that chronic kidney disease (CKD) is an independent predictor of hypoglycemia which is in turn associated with increased risk of mortality in T2D(Chu et al., 2017; Moen et al., 2009). The modifiable risk factors for CKD include poor glycemic control, hypertension, dyslipidemia, smoking, low-grade inflammation, advanced glycation end products, physical inactivity, and salt intake (Harjutsalo & Groop, 2014). Targeting these risk factors is needed for the effective prevention and management of CKD in T2D with comorbid HF (Chadban et al., 2010). Emphasis placed on effective glycemic control, the use of antihypertensive and lipid lowering therapies, and lifestyle modifications including smoking cessation, diet, and physical activity for the prevention and management of CKD in people with T2D and comorbid HF.

The total daily medication was an independent predictor of impaired FBG in the present study. Given that T2D-HF patients in our study were taking on average 12 or more medications per day, the burden associated with the medication regimen likely impacts treatment adherence which can lead to poorer glycemic control (Bluher, Kurz, Dannenmaier, & Dworak, 2015; Saundankar et al., 2016). The medication burden may be related to the high number of comorbidities observed in our study participants. The use of a fixed-dose combination drugs to treat common comorbid conditions (Moore et al., 2018) may need to be considered to reduce medication burden and improve FBG in people with T2D and comorbid HF.

Strength and limitations

There were several strengths of this study. Examining the influence of HF on T2D self-care behaviors has not been previously reported. The study included a population of predominately African American males who have received less attention regarding T2D self-care behaviors. The findings from this study add to knowledge about self-care behaviors in this demographic group. The sample was recruited from 4 urban, academic tertiary care centers with specialized HF clinics where guidelines for HF are utilized. There were also several limitations including the ability to generalize beyond African American males to other populations such as women and Caucasians. Another limitation was the cross-sectional nature of the study design which prevented examination of temporal associations over time. Although confounders were included in our statistical analyses, it is possible that some bias may have occurred and findings should be interpreted with caution. As with any secondary analysis, we were limited by measures selected in the parent study.

Conclusion

An integrated self-care framework was used to explore the association between diabetes self-care behaviors and glycemic control in people with T2D and comorbid HF. Although none of the diabetes self-care behaviors independently predicted glycemic control, some demographic and clinical variables emerged as independent predictors. Many of the clinical variables such as medication regimens that included insulin or combination therapy, number of comorbidities and number of daily medications may be a proxy for more progressive disease and higher disease burden resulting in poorer glycemic control. The findings suggest that the presence of other comorbidities may heighten the complexity of performing diabetes self-care, leading to poorer glycemic control. An unanticipated finding was that none of the diabetes self-care behaviors influenced glycemic control. This suggests that the burden associated with having multiple chronic conditions may be an important factor to consider when evaluating ability to perform effective diabetes self-care in persons with T2D. Findings from this study indicate that future research should target multi-morbidity and how to best manage these complex self-care and treatment regimens to improve health outcomes and quality of life.

CHAPTER V

INTEGRATIVE SUMMARY

The purpose of this study was to provide a deeper conceptual understanding of the correlates of diabetes self-care behaviors in adults with T2D and comorbid HF. The specific aims of the study were:

Aim 1: Characterize the sociodemographic and clinical correlates of diabetes self-efficacy in adults with T2D and comorbid HF.

Aim 2: Describe the correlates of diabetes self-care behaviors in adults with T2D and comorbid HF.

Aim 3: Determine the relationship between diabetes self-care behaviors and glycemic control in adults with T2D and comorbid HF.

Studies have identified that people with T2D have proportionately higher rate of comorbid HF compare to the general population (Einarson et al., 2018; Roger, 2013). People with comorbid T2D and HF have a 36% increased risk for hospitalization (Kamalesh & Cleophas, 2009), 31.5% for rehospitalization (Greenberg et al., 2007), development of cardiovascular complications (Cavender et al., 2015), and higher risk of cardiovascular and all-cause mortality (Bauduceau et al., 2018; Cavender et al., 2015; Kristensen et al., 2017; Kristensen et al., 2016). For example, a study demonstrated that incident HF in T2D is associated with a 10-fold increased risk of mortality and with 12.5% of 5-year survival rate compared to above 80% in those without HF (Bertoni et al., 2004). People with comorbid T2D and HF also have poorer NYHA functional class, higher HF-related symptoms, lower quality of life, and worse exercise tolerance (Kristensen et al., 2017; Kristensen et al., 2016).

Theoretical Framework

This study used a theoretical model for an integrated diabetes self-care for adults with type 2 diabetes mellitus (T2D) and comorbid heart failure (HF). Adapting an integrated conceptual framework originally developed to guide HF self-care (Dunbar et al., 2008) the relationships of the variables were arranged around antecedents and outcomes of diabetes self-care behaviors. The antecedent factors included an individual's demographic, clinical and psychosocial factors. The markers of glycemic control, glycated hemoglobin (HbA1c) and fasting blood glucose (FBG) were included in the model as outcomes of diabetes self-care behaviors. The variables of each antecedent factor were analyzed to determine their relationship with diabetes self-care behaviors. From the psychosocial factors, diabetes self-efficacy is recognized as a prominent indicator of better diabetes self-care behaviors (Amer, Mohamed, Elbur, Abdelaziz, & Elrayah, 2018; Gurmu et al., 2018; Tharek et al., 2018) but can be influenced by myriad of sociodemographic and clinical factors (Bohanny et al., 2013; Burner et al., 2013; Choi et al., 2015; Cosansu & Erdogan, 2014; S. K. A. Sharoni & Wu, 2012; S.-F. V. Wu et al., 2013). The individual sociodemographic and clinical factors relationships with diabetes self-efficacy were analyzed in this study. Moreover, the relationship between diabetes self-care behaviors and glycemic control was analyzed while adjusting for demographic, clinical, and psychosocial factors.

The proposed theoretical model incorporates factors correlated with diabetes self-efficacy, diabetes self-care behavior, and diabetes outcomes (HbA1c and FBG). Figure 5.1 delineates sociodemographic and clinical factors associated with diabetes self-efficacy in adults with T2D and comorbid HF addressed in manuscript 1.

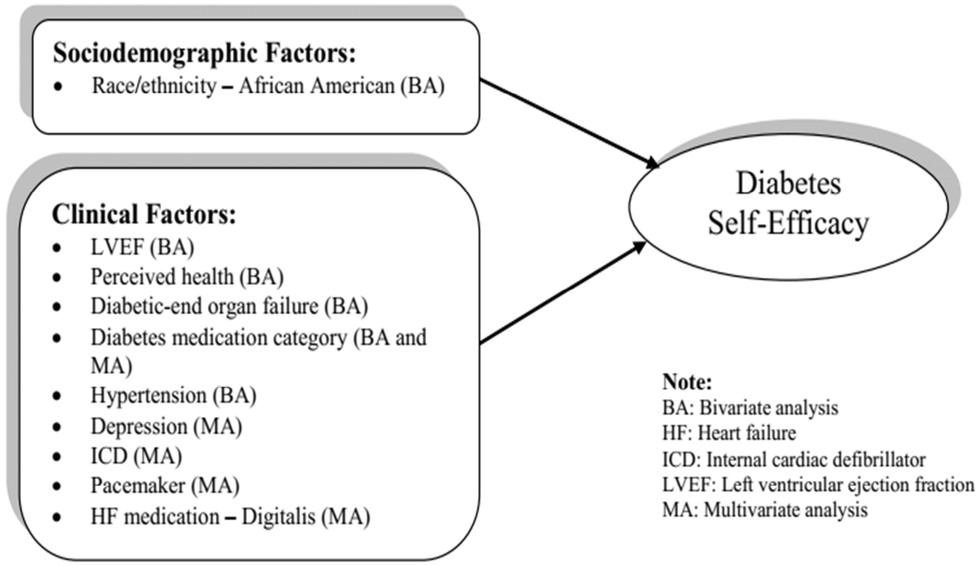

Figure 5-0-1 Factors associated with diabetes self-efficacy in people with T2D comorbid HF

Figure 5.2 portrays demographic, clinical, and psychosocial factors associated with diabetes self-care behaviors (blood glucose self-monitoring, foot care and exercise) presented in manuscript 2.

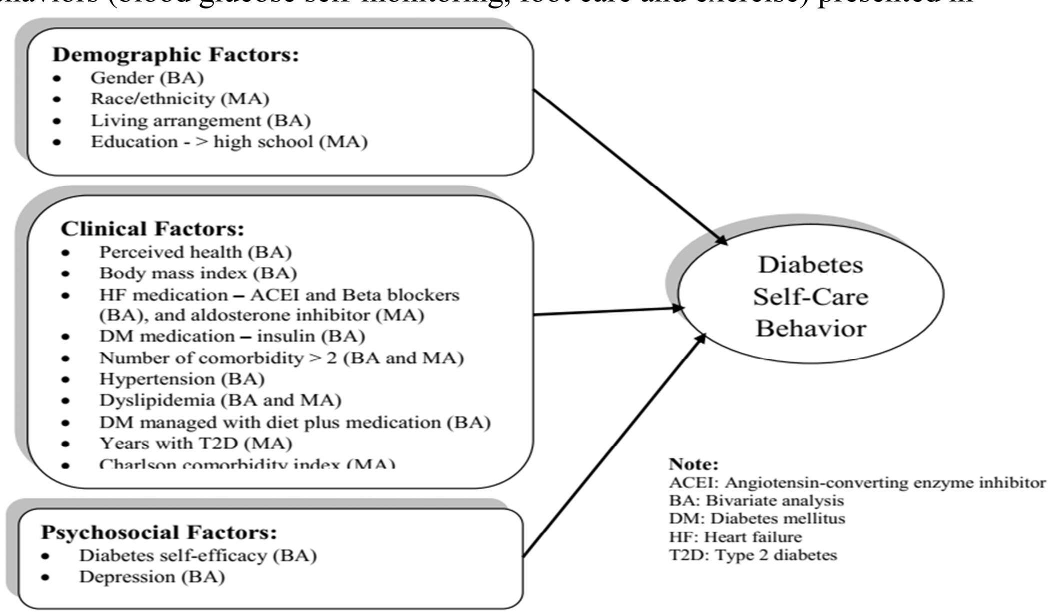

Figure 5-0-2 Factors associated with diabetes self-care behaviors in people with T2D and comorbid HF

Figure 5.3 outlines demographic, clinical and psychosocial factors, and diabetes self-care behaviors associated with markers of glycemic control (HbA1c and FBG) in manuscript 3.

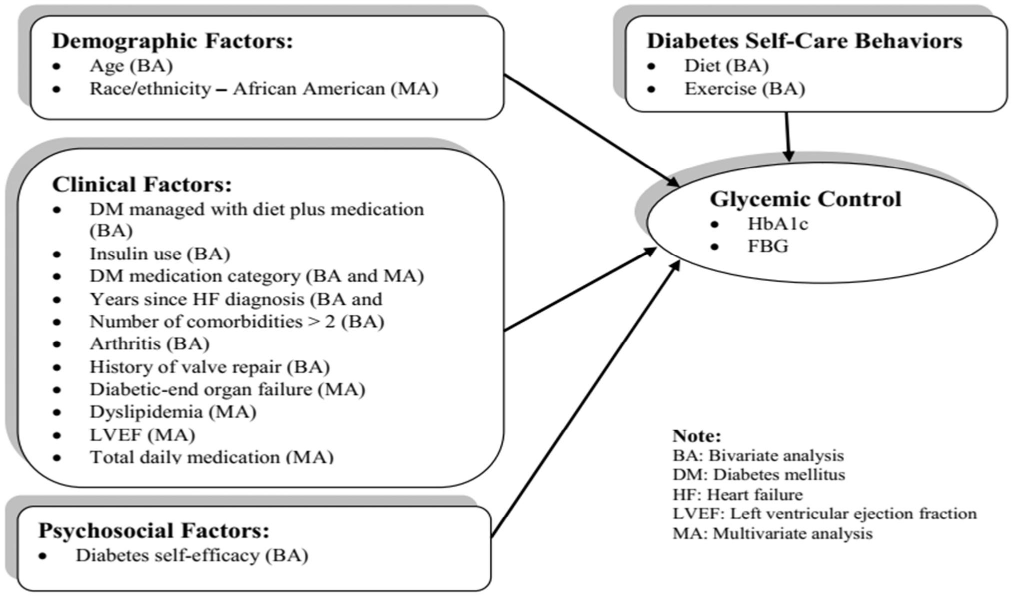

Figure 5-0-3 Factors associated with glycemic control in people with T2D and comorbid HF

Figure 5.4 presents the proposed model of integrated diabetes self-care for people with T2D and comorbid HF.

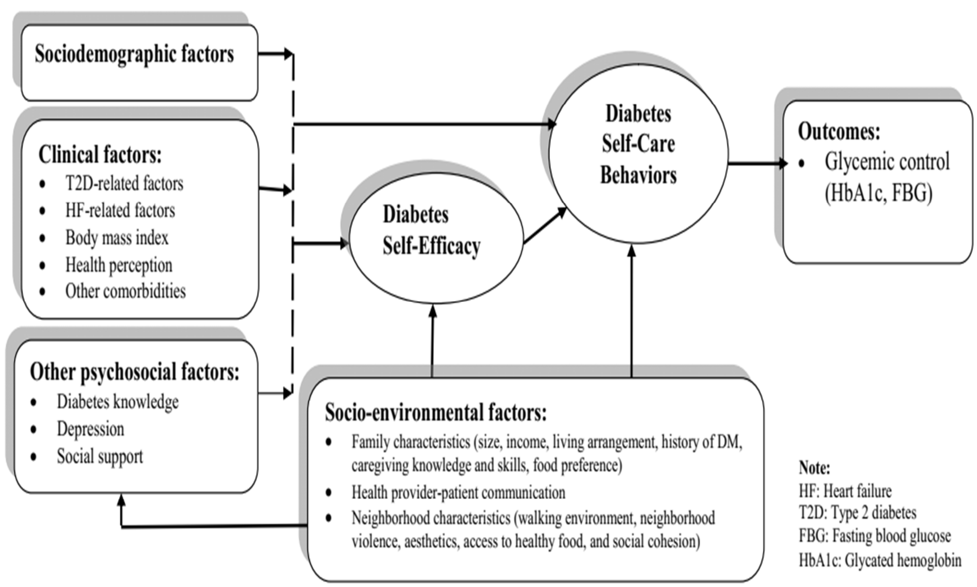

Figure 5-4 Model of integrated diabetes self-care for people with T2D and comorbid HF

Many of the sociodemographic, clinical, and psychosocial factors delineated in the present study also align with the results of previous studies in adults with T2D. Studies in T2D have consistently shown that higher diabetes self-efficacy is associated with greater diabetes self-care behaviors (Gurmu et al., 2018; E.-H. Lee et al., 2016; Walker et al., 2014). Sociodemographic factors including gender (Choi et al., 2015; Watkins et al., 2013) and educational level (Cosansu & Erdogan, 2014; Gurmu et al., 2018) are associated both with diabetes self-efficacy and self-care behaviors. Studies have also demonstrated the association between ethnicity and diabetes self-care behaviors in T2D (Hyman et al., 2014; Johnson et al., 2014). Clinical factors such as duration of T2D and comorbidities influence diabetes self-care behaviors likely through the effect on diabetes self-efficacy (S. K. A. Sharoni & Wu, 2012; S.-F. V. Wu et al., 2013). Studies have also persistently shown that psychosocial factors including diabetes knowledge (Ghannadi et al., 2016; Kassahun et al., 2016; Kueh et al., 2015; Waheedi et al., 2017), depression (Maneze et al., 2016; Sumlin et al., 2014; Walker et al., 2014), and social support (Rosland et al., 2014; Smalls et al., 2014, 2015a, 2015b; Vaccaro et al., 2014; Vissenberg et al., 2016) are associated with diabetes self-care behaviors in people with T2D.

Though not addressed in the present research, previous studies in T2D have demonstrated that socio-environmental factors including family (Baig et al., 2015; Vaccaro et al., 2014) and neighborhood (Juarez-Ramirez et al., 2015; Smalls et al., 2014, 2015a, 2015b; Vijayaraghavan et al., 2011) characteristics influence social support, self-efficacy, and diabetes self-care behaviors. Provider-patient communication is also associated with diabetes self-care behaviors (J. Gao et al., 2013). This suggests the need to incorporate socio-environmental factors in diabetes self-care intervention.

Implications for Practice and Research

The major finding from this study is that the conventional disease-specific approach to diabetes self-care does not improve outcomes in people with T2D and comorbid HF. This was shown by the lack of influence of diabetes self-care behaviors' on HbA1c and FBG. Other factors including African America race, diabetic-end organ failure, dyslipidemia, HF severity, and medications however, did influence these outcomes. This information underscores the importance of shifting from the conventional disease-specific diabetes self-care intervention to a more integrative one for people with T2D and comorbid HF. Integrated care models in other comorbid chronic illnesses have shown significant improvement in patient outcomes (Bourbeau & Saad, 2012; Dunbar et al., 2014; Dunbar et al., 2015), quality of life and reductions in health care costs (Katon et al., 2012; Reilly et al., 2015).

The provision of integrated diabetes self-care in T2D-HF comorbidity requires addressing the self-management education and support needs of both conditions. For example, since HF symptoms often result in frailty (Boxer et al., 2014) and cognitive impairment (Leto & Feola, 2014) addressing how to self-manage these symptoms would help to enhance the T2D-HF patient's ability for self-care that ultimately improves diabetes-related outcomes. Evaluating the impact of other comorbid conditions such as depression and diabetic-end organ failure on the patient's ability to perform diabetes self-care is also essential to improve patient outcomes. Similarly, it is necessary to assess the impact of medication burden including drugs side effects on the T2D-HF patient's capacity for self-care.

Incorporating socio-environmental components in diabetes self-care intervention for people with T2D and comorbid HF is also essential. For example, the supports that family members or relatives provide potentially enrich the patient's sense of belonging, self-efficacy and self-care. However, the ability to provide the patient with the necessary social support can be influenced by family-related variables such as living arrangement, income, caregiving knowledge and skills and food preferences (Baig et al., 2015; Vaccaro et al., 2014) and neighborhood factors including walking environment, social cohesion, neighborhood violence, aesthetics, poor housing and access to healthy foods (Juarez-Ramirez et al., 2015; Smalls et al., 2014, 2015a, 2015b; Vijayaraghavan et al., 2011). Identifying and addressing these factors is important to improve the family's ability to provide the patient with the necessary support. Health provider's communication skills can also influence the T2D-HF patient's self-efficacy for diabetes self-care (Inoue, Takahashi, & Kai, 2013; Nam, Nam, & Song, 2014). Thus, addressing these factors can help to improve self-efficacy and self-care behaviors in this population group.

Strength and Limitations of the Study

Comorbid chronic illnesses are prevalent and increase disease burden and cost of care in people with T2D (Lin et al., 2015). Research studies that addresses these comorbidities would lead to into more effective interventions (Dunbar et al., 2014; Smith et al., 2012). Most studies investigating diabetes self-care behaviors in T2D however, have not considered comorbid conditions (Ouyang et al., 2015; Park et al., 2015; Tshiananga et al., 2012; Zheng et al., 2019). As a consequence, how patients' engage in self-care behaviors in the presence of other comorbid illnesses is largely unknown. Exploring for the first time the correlates of diabetes self-care behaviors in adults with T2D and comorbid HF is a major strength of this study. In addition, the largely male and African American study sample was a strength since less is known about this T2D subgroup and their self-care practices. An important concern when exploring the association between predictors and outcome variables is confounding. In this study, an attempt was made to control for the covariates and reduce the threat to bias using stepwise logistics and linear regression models. A cross-sectional design does not allow identifying the temporal dimension of the variables or infer causality. In addition, whether findings from this study can be generalized to other populations such as women with T2D and comorbid HF or Caucasians is unknown.

The medication adherence dimension was not measured in the baseline data despite an instrument (SDSCA) with established validity and reliability was used to measure diabetes self-care behaviors. In addition, the social support (ESSI) had high missing values (n = 62) that limited its sample size for the analysis in this study though not treated as an outcome variable.

Summary

The purpose of this study was to provide a deeper conceptual understanding of the correlates of diabetes self-care behaviors in adults with T2D and comorbid HF. This study identified demographic, clinical, and psychosocial factors associated with diabetes self-care behaviors. It also identified sociodemographic and clinical factors associated with diabetes self-efficacy. Nevertheless, the diabetes self-care behaviors' lack of influence of HbA1c and FBG is a major finding of this study. This underscores that the conventional disease-specific approach to diabetes self-care intervention cannot help to improve patient outcomes in people with T2D and comorbid HF. Therefore, it is imperative to shift from disease-specific approach to integrated diabetes self-care model to improve outcomes for this population.

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ANNEX: DECLARATION

DECLARATION OF DISSERTATION WORK

I, the under signed, declare that this dissertation – *Correlates of Diabetes Self-Care Behaviors in Adults with Type 2 Diabetes and Comorbid Heart Failure* – is my original work, has never been presented in this or any other University, and that all the resources and materials used for the dissertation have been fully acknowledged.

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This dissertation has been submitted for defense/examination with my endorsement as the student's dissertation committee member.

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