

Digital Health for Diabetes Self-Management Among Black Men:
Barriers, Facilitators, and User Preferences

by

Anna Maria Diané

Department of Nursing
Duke University

Date: _____

Approved:

Ryan J. Shaw, Supervisor

Tolu Oyesanya

Schenita D. Randolph

Adriana Arcia

Dissertation submitted in partial fulfillment of
the requirements for the degree of Doctor of Philosophy in Nursing
in the Graduate School of Duke University

2023

ABSTRACT

Digital Health for Diabetes Self-Management Among Black Men:
Barriers, Facilitators, and User Preferences
by

Anna Maria Diané

Department of Nursing
Duke University

Date: _____

Approved:

Ryan J. Shaw, Supervisor

Tolu Oyesanya

Schenita D. Randolph

Adriana Arcia

An abstract of a dissertation submitted in partial fulfillment of
the requirements for the degree of Doctor of Philosophy in Nursing
in the Graduate School of Duke University

2023

Copyright by
Anna Maria Diané
2023

Abstract

This dissertation aimed to explore the barriers, facilitators, and user preferences of digital health use for diabetes self-management among Black men while also investigating clinicians' perspectives of digital health use for clinical decision making and management of diabetes. Chapter one contains an introduction to digital health and diabetes management among Black men, followed by gaps in the literature and aims addressed within this dissertation. Chapter Two is a study designed to evaluate the barriers and facilitators to digital health use for self-management of diabetes among Black men. Chapter Three is a study intended to investigate desired design requirements for a diabetes self-management app among Black men living with diabetes with Black men as the key stakeholders. Chapter Four is a study constructed to evaluate clinicians' perspectives of the utility of patient generated health data to guide clinical decision making and self-management of diabetes. Chapter five provides an overall review of the dissertation, a discussion on the implications of the research, study limitations, and directions for future research.

Contents

Abstract.....	iv
List of Tables.....	viii
List of Figures.....	ix
Acknowledgements.....	x
1 Introduction.....	1
1.1 Background.....	1
1.2 Digital Health and Diabetes Management Research among Black Men.....	10
1.3 Dissertation Organization and Aims.....	13
2 Barriers and Facilitators to Using Digital Health to Self-Manage Diabetes: A Qualitative Study of Black Men’s Perspectives.....	17
2.1 Introduction.....	17
2.2 Methods.....	24
2.3 Data Collection.....	25
2.4 Data Analysis.....	26
2.5 Results.....	29
2.6 Discussion.....	53
2.7 Conclusion.....	57
3 Desired mHealth App Features to Facilitate Self-Management among Black Men with Diabetes: A Qualitative Study.....	58
3.1 Introduction.....	58
3.2 Methods.....	63
3.3 Data Collection.....	65
3.4 Data Analysis.....	66

3.5	Results.....	68
3.6	Discussion	84
3.7	Conclusion	89
4	Clinicians’ Perceptions of using Patient-Generated Health Data to Guide Clinical Decision-Making and Management of Diabetes: A Qualitative Study ...	91
4.1	Introduction	91
4.2	Methods.....	94
4.3	Data Collection.....	95
4.4	Data Analysis.....	97
4.5	Results.....	100
4.6	Discussion	113
4.7	Conclusions.....	116
5	Conclusion	118
5.1	Summary of Results and Key Findings	118
5.2	Nursing Implications.....	120
5.3	Health Policy Implications	121
5.4	Limitations and Strengths.....	122
5.5	Future Research.....	124
5.6	Closing.....	126
	Appendix A.....	127
	Appendix B	128
	Appendix C.....	131
	Appendix D.....	133
	Appendix E	137

References 138
Biography 153

List of Tables

Table 1: Organization of Chapters, Manuscript Titles and Aims	14
Table 2: Scientific Rigor Strategies	29
Table 3: Participant Demographics.....	30
Table 4: Participant Demographics.....	69
Table 5: Strategies used to Establish Scientific Rigor	99
Table 6: Participant Demographics.....	100

List of Figures

Figure 1: Factors Impacting use of Health Technology to Manage Diabetes among Black Men	31
Figure 2: Illustration of Themes and Subthemes	70

Acknowledgements

Acknowledgements: Special thanks to dissertation committee members: Ryan J. Shaw, PhD, RN, (Chair); Tolu Oyesanya, PhD, RN; Adriana Arcia, PhD, RN; and Schenita D. Randolph, PhD, RN. Thank you to the School of Nursing faculty and staff.

Funding: This research was funded by the National Institute of Nursing Research (NINR) under Grant 5F31NR019213. The content is solely the responsibility of the author(s) and does not necessarily represent the official views of NINR/NIH.

Conflicts of Interest: The author reports there are no competing interests to declare.

1 Introduction

1.1 Background

Diabetes is a significant chronic health problem in the United States, affecting 37.3 million Americans, or approximately 10% of the population (CDC, 2022). With a 60% increased prevalence and the seventh greatest cause of mortality, diabetes has cost around \$327 billion in medical costs and lost income annually (Adu et al., 2019; CDC, 2022). In addition to costs, there are numerous diabetes-related consequences for patients. If left uncontrolled, diabetes can affect numerous body systems causing heart disease, renal disease, damage to the neurological system, vision impairment and blindness, loss of hearing, poor oral health, and death (ADA, 2019). According to the CDC (2022), people with diabetes incur more than twice as many medical expenses as those without diabetes. Additionally, diabetes disproportionately affects minority communities such as Black individuals and those of Hispanic heritage (CDC, 2022).

Diabetes and Black Men

Diabetes is a serious health condition that impacts people of all races and genders in the United States. However, research shows that Black men are disproportionately affected by diabetes compared to other racial and gender groups. According to the CDC (2022), the age-adjusted prevalence of diagnosed

diabetes among non-Hispanic Black adults is 13.2%, which is higher than the prevalence among non-Hispanic White adults (7.5%) and Hispanic adults (12.5%). In addition to a higher prevalence, Black men are twice as likely as White men to experience diabetes-related complications, such as kidney disease, amputations, and vision loss (CDC, 2020). The American Heart Association (2022) reports that Black men with diabetes are at a greater risk of hospitalization, end-stage renal disease, and mortality compared to non-Black individuals with diabetes.

Despite efforts to reduce health disparities among Black men with diabetes, diagnosis rates continue to increase. Diagnoses in this group climbed 160 percent from 1980 to 2020 (HHS.gov, 2021; CDC, 2022; Hurt et al., 2020). There are several factors that contribute to the higher prevalence of diabetes among Black men compared to all other racial and gender groups. The impact of social determinants of health on the health outcomes of Black men with diabetes cannot be ignored (Hill-Briggs et al., 2015; Powell et al., 2019; Hill-Briggs et al., 2022). These determinants include socioeconomic status, physical environment, food environment, healthcare, and social context, all of which have been influenced by historical racism and discrimination (Hill-Briggs et al., 2022; Ogunwole & Golden, 2021). At a broader level, there are disparities in the

circumstances in which Black Americans are “born, raised, reside, work, and age, in contrast to those experienced by White Americans” (Hill-Briggs et al., 2022).

For example, the disparities in the circumstances that Black Americans experience compared to White Americans, such as differences in living conditions and housing situations, are an outcome of past US policies and practices of segregating neighborhoods by race, redlining, zoning, and limiting access (Eisenhauer, 2001; Rothstein, 2017; Ogunwole & Golden, 2021).

As a result, Black men are more likely to live in socioeconomically disadvantaged neighborhoods with limited access to healthcare, healthy food options, and opportunities for physical activity (Golden et al., 2017). This has contributed to differences in food availability, environmental toxicity, and access to healthcare for Black men (Eisenhauer, 2001; Rothstein, 2017; Ogunwole & Golden, 2021). Research has shown that these persistent inequalities contribute to the high prevalence of diabetes and related complications among Black men (Hill-Briggs et al., 2022).

Black men also encounter more difficulties in managing diabetes compared to non-Hispanic White men due to unequal access and delivery of healthcare services as a result of clinician bias, lack of social support, long work hours, and skepticism and cultural beliefs concerning the medical system as a

result of historical abuse from the medical system and research (Chlebowy et al., 2010, 2013; Ricci-Cabello et al., 2013; Hawkins et al., 2022; Mayberry et al., 2021; Rony et al., 2022). For example, cultural beliefs, such as the stigma surrounding chronic illness in the Black community, can also impact diabetes self-management among Black men (Owens et al., 2017). These factors, combined with a lack of tailored diabetes self-management interventions, can make it difficult for Black men to self-manage their diabetes effectively (Hill-Briggs et al., 2016). Addressing the diabetes problem among Black men requires a multifaceted approach that considers the complex interplay of factors. These challenges highlight the need for targeted interventions that address these specific issues and promote diabetes management among Black men.

Digital Health and Diabetes Management

Achieving optimal outcomes in diabetes requires stringent self-management. The goal is to control blood glucose levels, which is one of the most important factors in preventing complications associated with diabetes (ADA, 2019). Effective self-management involves multiple efforts including changing one's diet by reducing carbohydrate intake and increasing consumption of low-glycemic foods, increasing physical activity, monitoring blood glucose levels at suitable intervals, adhering to prescribed medication, and attending

appointments with healthcare providers (ADA, 2019). Self-management of diabetes is a complex process that requires not only the motivation, knowledge, and skill to improve one's health effectively but also an adequate social support system, often consisting of friends, family, and healthcare experts (Adu et al., 2019).

The use of digital health has become increasingly popular for managing diabetes and has shown a diverse range of self-management success. Current digital health interventions aimed at managing diabetes include blood glucose and insulin management mobile applications, wearable and continuous blood glucose meters, automated text messaging interventions, health diaries or logs, and virtual health coaching (Shan et al., 2019). These digital health tools monitor blood glucose levels, calculate medicine dosages, monitor nutrition and exercise, and provide educational opportunities. Previous studies indicate that they can improve adherence to drug regimens, decrease weight, blood pressure, and HbA1c levels, and increase physical activity (Ehrmann et al., 2022). Patients can track their health data, learn self-care behaviors, and increase their health status awareness with digital health tools (Villalobos et al., 2020). Furthermore, systematic evaluations found that the usage of mobile applications has a positive correlation with improved diabetes control and self-management (Ali et al., 2016;

Byambasuren et al., 2018; Dugas et al., 2020; Fortuin et al., 2016; Kebede & Pischke, 2019; Mao et al., 2020; Marcolino et al., 2018).

There is evidence that use of mobile applications can reduce hemoglobin A1c values by as much as 0.8% and 0.3% in individuals with type 1 and type 2 diabetes, respectively, compared to patients receiving standard care for their condition (Kitsiou et al., 2017). In smartphone applications, also known as “apps”, with only basic features, users are reminded of their glycemic targets and supplied with patient education. In more extensive apps, users receive customized education that automates diet, exercise, self-care, and monitoring messages. These more extensive apps demonstrate a 0.7% decrease in HbA1c levels after six months, as well as improved diets, foot care, and more regular blood glucose monitoring among users (Nundy et al., 2014). Smartphones can act as an indispensable link between blood glucose monitoring equipment, patients, and healthcare professionals by offering seamless connectivity.

Blood glucose monitoring equipment, such as continuous glucose monitoring (CGM) devices have become increasingly popular. CGM devices measure glucose levels in the interstitial fluid using a small sensor inserted under the skin, typically on the abdomen or arm (American Diabetes Association, 2019; Hughes et al., 2023). These devices provide real-time display of blood glucose

readings, trends or deviations in glucose levels, and alerts for hyper- or hypoglycemic events, allowing for prompt action to be taken (Rodbard, 2016; American Diabetes Association, 2019). Furthermore, CGM provides insights into how daily activities such as exercise, diet, and stress affect blood glucose levels, which can help patients make informed decisions about their diabetes management, leading to improved glycemic control and potentially reducing the risk of complications (Smith et al., 2019).

CGM can also provide a more complete picture of glucose control than traditional glucose monitoring methods, as it provides continuous glucose readings throughout the day and night. Literature has found that the use of CGM devices in people with diabetes led to improvements in glycemic control, a reduction in the frequency and severity of hypoglycemic events, and an increase in time spent in target blood glucose range (Maiorino et al., 2020; Kieu et al., 2022; Ida et al., 2019). Overall, CGM devices have the potential to greatly benefit people with diabetes by providing continuous glucose data and enabling informed decision-making for self-management.

The Role of Clinicians

Clinicians, including physicians, nurse practitioners, and nurses, play a crucial role in the integration of digital health tools into diabetes management.

They are responsible for recommending and prescribing appropriate digital health tools to their patients and monitoring their use and effectiveness (American Diabetes Association, 2019). Clinicians can also use digital health tools to remotely monitor their patients' glucose levels, medication adherence, and other health metrics, enabling them to provide timely feedback and adjust treatment plans as needed (Shan, 2019; Sezgin et al., 2019). Moreover, digital health tools can enhance patient-clinician communication, allowing for more frequent and efficient exchanges that can improve patient outcomes (Qudah & Luetsch, 2019). However, clinicians need to be knowledgeable about the various digital health tools available and understand how they can be used to benefit their patients effectively. They also need to be aware of the potential limitations and drawbacks of these tools to ensure that they are being used appropriately. Therefore, continuing education and training are necessary to equip clinicians with the skills and knowledge required to incorporate digital health tools into diabetes management successfully (American Diabetes Association, 2019).

In terms of diabetes management, mobile health applications and other updated healthcare modalities provide substantial time and cost savings opportunities. Evidence suggests that digital health applications and telemedicine reduce the time clinicians spend with patients in the office, decrease

patient commute times to appointments, decrease patient waiting times to see a physician, and reduce time off from work for adults with diabetes and their caregivers (Ashrafzadeh & Hamdy, 2019). Additionally, the utilization of patient-generated health data (PGHD) by digital health applications has the potential to transform and direct clinical care (Shaw, 2020). More specifically, PGHD is anticipated to contribute to the prevention, monitoring, and treatment of diabetes in various groups (Bode et al., 2021). Moreover, digital health can significantly improve the individualization of clinical decision-making in order to enhance diabetic self-management and health outcomes. Future success in expanding the use of diabetes management tools depends not just on user adoption but also on clinician support.

One study demonstrated that clinicians considered PGHD useful for assessing self-care, barriers such as cost, self-efficacy, and patient awareness of diabetes, as well as self-care assessments (Doyle-Delgado & Chamberlain, 2020). This information is helpful for scheduling patient appointments and determining which components of patient education will be most beneficial for specific patients. In circumstances when patient-provider communication was not excellent, the data generated by digital apps were still valuable (Doyle-Delgado & Chamberlain, 2020).

1.2 Digital Health and Diabetes Management Research among Black Men

Digital health presents a unique opportunity to engage Black men with diabetes in an unprecedented manner. Given that 99% of all Black Americans own a cell phone and 83 percent have a smartphone, digital health can be a good solution for Black men with diabetes because it can provide a convenient and accessible way to manage their health (Pew Research Center, 2021). As discussed earlier, Black men face obstacles in managing their diabetes, such as lack of access to care, social and cultural barriers, and competing demands (Hawkins, 2019; Hurt et al., 2020). Digital health tools, such as mobile applications and CGM devices, can help overcome some of these barriers by providing real-time access to health data, personalized feedback, and educational resources (American Diabetes Association, 2019). Digital health interventions have the ability to be tailored to meet the specific needs and preferences of certain populations, like Black men with diabetes, which can help address the unique health challenges and disparities present. Additionally, digital health interventions have the potential to overcome geographic barriers and provide access to health information and resources that may not be available in traditional healthcare settings to Black men (Grande & Sherman, 2018). While research has shown that digital health technologies are a useful, effective, and

affordable, opportunity to promote diabetes related management, there is a lack of targeted and tailored research being conducted among Black men (Hawkins, 2019).

To make digital health applications more acceptable and effective, it is suggested that the features be customized to the user's cultural background and values (Donnelly, 2020). Cultural tailoring ensures the perspectives of a population are respected and adequately addressed within the intervention design (Ruiz et al., 2018). It is especially important to respect cultural sensitivity when developing digital health interventions for Black men because the factors associated with effective diabetes self-management are likely to be unique and different from men from other racial groups and women in general (Jack et al., 2010; Hurt et al., 2015). Culturally tailored interventions that consider the social and cultural contexts in which individuals live and can help address these barriers by providing relevant and meaningful health information and resources (Ruiz et al., 2018). By tailoring digital health interventions to the specific needs and preferences of black men, these interventions can be more effective in promoting positive health outcomes and reducing health disparities. One study demonstrated that if mobile health technology is integrated with physical

activity and culturally appropriate discussions and care, the self-management of diabetes in Black men improve (Carthron et al., 2021; Hawkins et al., 2022).

Given disparities in diabetes outcomes and noted barriers to self-management, it is crucial to solicit Black men's input to effectively inform research and development of tailored digital health technologies designed to reduce healthcare disparities. Research is currently not adequately addressing the unique experiences and viewpoints of Black men with diabetes, as there is an extreme lack of research that incorporate their perspectives. Black men have only compromised an average of 15% of sample sizes in diabetes research in general on non-Hispanic Black men and women in the last 20 years (Newton et al., 2015; Hawkins, 2019; Sherman et al., 2017; Jack et al., 2010). The number is even lower for studies involving use of digital health for diabetes management. Insufficient attention has been centered on the recruitment and engagement of Black men in diabetes research (Hawkins, 2019; Hurt et al., 2020, Jack et al., 2010). The corresponding lack of work on the development of diabetes self-management strategies which address the barriers uniquely faced by Black men contributes to an extreme gap in the research literature (Hawkins, 2019; Sherman et al., 2017; Jack et al., 2010). Thus, these healthcare disparities can only be mediated by

engaging Black men in diabetes research and in the development of digital health intervention for diabetes management.

While digital health holds great promise to facilitate diabetes self-management and care, data are lacking to inform the development and testing of digital health solutions tailored to Black men with diabetes. There is a critical need to better engage Black men with diabetes as key stakeholders in research to assess their unique needs to inform the development and testing of tailored applications to help mitigate these existing racial disparities in diabetes outcomes.

1.3 Dissertation Organization and Aims

The current dissertation consists of three manuscripts that cover three chapters (see Table 1).

Table 1: Organization of Chapters, Manuscript Titles and Aims

Chapter	Title	Aim
Two	Barriers and Facilitators to Using Digital Health to Self-Manage Diabetes: A Qualitative Study of Black Men's Perspectives	1. To evaluate the barriers and facilitators to digital health use for self-management of diabetes among Black men
Three	Desired mHealth App Features to Facilitate Self-Management among Black Men with Diabetes: A Qualitative Study	2. To investigate design requirements for a diabetes self-management app for Black men
Four	Clinicians' Perceptions of using Patient Generated Health Data to Guide Clinical Decision Making and Management of Diabetes	3. To explore clinicians' perspectives of the utility of patient generated health data to guide clinical decision making and self-management of diabetes

This dissertation aimed to explore the barriers, facilitators, and user preferences of digital health use for diabetes self-management among Black men while also investigating clinicians' perspectives of digital health use for clinical decision making and management of diabetes.

The qualitative study described in Chapter Two aimed to evaluate the barriers and facilitators to digital health use for self-management of diabetes among Black men. Participants were also invited to describe cultural factors that influence their use of digital health for diabetes management in order to provide further insight and knowledge about their desired digital health solutions.

Qualitative semi-structured interviews with were conducted among 20 Black men living with diabetes in the United States.

The same interviews and cohort were used for the qualitative study described in Chapter Three which aimed to investigate desired design requirements for a diabetes self-management app among Black men living with diabetes with Black men as the key stakeholders.

The qualitative study described in Chapter Four aimed to evaluate clinicians' perspectives of the utility of patient generated health data to guide clinical decision making and self-management of diabetes. Qualitative semi-structured interviews with were conducted among a diverse group of 21 healthcare professionals, including physicians, nurse practitioners, diabetes educators and registered nurses at an academic health center in the Southeastern United States.

Study data were analyzed using conventional content analysis, which allowed the results to be developed directly from the data, which is preferable for areas where there are few previous studies focusing on the phenomenon or when research in is the area is fragmented (Elo & Kyngas, 2008; Hsieh & Shannon, 2005).

Chapter five provides an overall summary of the dissertation, a discussion on the implications of the research, identifies study limitations, and offers recommendations for future research. Together these chapters provide insights into various factors affecting the adoption and utilization of digital health technologies for diabetes self-management among Black men, including barriers, facilitators, and user preferences as well as the perspectives of clinicians on the use of digital health for clinical decision making and managing diabetes.

2 Barriers and Facilitators to Using Digital Health to Self-Manage Diabetes: A Qualitative Study of Black Men's Perspectives

2.1 Introduction

Diabetes is a chronic disease that affects millions of people worldwide, with Black men being at a higher risk of developing the condition (ADA, 2022; CDC, 2022). While diabetes ranks seventh among the leading causes of death in the US, it is the sixth leading cause of death among Black men (ADA, 2022; CDC, 2022). Furthermore, Black men are three times more likely to be hospitalized for diabetes-related complications, to require amputation of a foot or leg due to diabetes, and to develop end-stage renal disease compared to non-Hispanic White men (CDC, 2022).

Despite efforts to decrease health disparities among Black men with diabetes, there has been an increase in diagnoses by 160% between 1980 and 2020 (HHS.gov, 2021; CDC, 2022; Hurt et al., 2020). The higher prevalence of diabetes among Black men compared to other racial and gender groups is largely attributed to social determinants of health such as socioeconomic status, physical environment, food environment, healthcare, and social context (Hill-Briggs et al., 2015). These determinants are influenced by historical racism and discrimination, leading to disparities in living conditions and housing situations for Black Americans (Eisenhauer, 2001; Rothstein, 2017; Ogunwole & Golden, 2021). As a

result, Black men are more likely to reside in disadvantaged neighborhoods with limited access to healthcare, healthy food options, and physical activity opportunities, which are factors that contribute to the high prevalence of diabetes and its complications among Black men (Hill-Briggs et al., 2015; Hill-Briggs et al., 2022; Golden et al., 2017).

Assari et al. (2017) state that the scientific evidence linking racial discrimination to poor health and health management (e.g., psychological and physiological stress responses, unhealthy coping behaviors, lower healthcare utilization) is overwhelming. Diabetes management requires frequent interactions with the healthcare sector; therefore, healthcare discrimination can have a significant negative impact on health and outcomes. Evidence suggests an association between perceived healthcare discrimination and the risk for receiving fewer hemoglobin A1c (HbA1c) tests and eye exams, lower quality health care, and poor patient-provider communication, all of which can lead to poorer diabetes-related outcomes (Assari et al., 2017; Piette et al., 2006; Ryan et al., 2008; Trivedi & Ayanian, 2006). These concerning statistics highlight the urgency to developing and implementing strategies aimed at reducing health disparities among Black men with diabetes.

It's important to note that diabetes is a complex health condition that requires stringent self-management, individualized care, and treatment (ADA, 2022). Effective self-management of diabetes involves various measures, such as making changes to one's diet by reducing carbohydrate intake and increasing low-glycemic food consumption, engaging in physical activity, monitoring blood glucose levels, taking prescribed medications, and attending follow-up care appointments with healthcare providers (ADA, 2022). Given that Black men face multiple barriers to proper diabetes management including lower social support, more negative patient-provider relationships, and the prohibitive cost of care, compared to other racial and gender groups, it is understandable that they tend to have worse diabetes-related health outcomes (Hawkins et al., 2022).

As diabetes continues to be a widespread health issue, many are turning to digital health interventions for managing their condition. These interventions come in various forms such as blood glucose and insulin management mobile applications, wearable and continuous blood glucose meters, automated text messaging interventions, health diaries or logs, and virtual health coaching (Shan et al., 2019). Through these devices, patients are able to monitor their blood glucose levels, calculate medicine dosages, track their nutrition and exercise, and access educational resources. Previous studies have shown that digital health

tools have improved drug regimen adherence, decreased weight, blood pressure, and HbA1c levels, and increased physical activity among end users (Ehrmann et al., 2022). They also enable patients to track their health data, learn self-care behaviors, and increase their health status awareness (Villalobos et al., 2020). Multiple systematic reviews have found a positive correlation between the use of mobile applications and improved diabetes control and self-management (Ali et al., 2016; Byambasuren et al., 2018; Dugas et al., 2020; Kebede & Pischke, 2019; Mao et al., 2020; Marcolino et al., 2018).

Multiple studies have demonstrated the positive effects of digital applications on personal behavior changes related to diabetes self-management, such as adherence to a low-glycemic diet, an increase in physical activity, and appropriate blood glucose monitoring; further, the literature suggests digital health applications have broader effects such as reduced geographical disparities, and lowered costs associated with diabetes care due to improved health outcomes. (Azelton et al., 2021; Boussageon et al., 2017; van Ommen et al., 2017). For example, the use of mobile applications in diabetes management has been found to significantly reduce HbA1c values by up to 0.8% and 0.3% in patients with type 1 and type 2 diabetes, respectively, compared to standard care (Kitsiou et al., 2017). Another study found that various features such as

reminders for glycemic targets, patient education and automated alerts for diet, exercise, and self-care, resulted in a 0.7% decrease in HbA1c levels after six months (Nundy et al., 2014). Furthermore, smartphones offer seamless connectivity between blood glucose monitoring equipment, patients, and healthcare professionals, making them an indispensable tool in diabetes management (Shaw, 2019).

Continuous glucose monitoring (CGM) devices have revolutionized blood glucose monitoring in recent years. These devices offer real-time glucose measurements using a small sensor inserted under the skin, usually in the arm or abdomen (American Diabetes Association, 2019; Hughes et al., 2023). Not only do they provide immediate feedback on glucose levels and alert users to any hyper- or hypo-glycemic events, but they also offer insights into how daily activities like diet, stress, and exercise affect blood sugar levels (Rodbard, 2016; American Diabetes Association, 2019). By providing continuous glucose readings throughout the day and night, CGM devices offer a more complete picture of glucose control than traditional monitoring methods (Smith et al., 2019).

Literature has shown that CGM use can lead to better glycemic control, fewer hypoglycemic events, and an increase in the amount of time spent within target

glucose ranges making them a valuable tool for diabetes self-management (Maiorino et al., 2020; Kieu et al., 2022; Ida et al., 2019).

As discussed earlier, Black men face several multiple obstacles in managing their diabetes, such as lack of access to care and systematic racism (Hawkins, 2019; Hurt et al., 2020). However, digital health tools, such as mobile applications and CGM devices, offer a unique opportunity to overcome these barriers. With 99% of Black Americans owning a cell phone and 83% having a smartphone, digital health presents a convenient and accessible solution for Black men with diabetes (Pew Research Center, 2021). By providing real-time access to health data, personalized feedback, and tailored educational resources, digital health can empower Black men with diabetes to take control of their health and improve their overall well-being in a way that may not be available in traditional healthcare settings for Black men (American Diabetes Association, 2019; Grande & Sherman, 2018). However, there is a lack of targeted and tailored research being conducted among Black men, despite the potential benefits of digital health technologies in promoting diabetes management (Hawkins, 2019).

Bridging healthcare disparities requires tailored digital health technologies that meet the needs and preferences of Black men with diabetes. Despite the need for research focused on capturing the perspectives of Black men

with diabetes, there is a significant lack of targeted research being conducted, with Black men accounting for only an average of 15% of sample sizes in diabetes research in the last 20 years (Newton et al., 2015; Hawkins, 2019; Sherman et al., 2017; Jack et al., 2010). This number is even lower for studies on digital health for diabetes management (Hawkins, 2019; Hurt et al., 2020). The limited engagement of Black men in diabetes research has led to an extensive gap in the literature on diabetes self-management strategies that address the self-management barriers unique to this population (Hawkins, 2019; Hurt et al., 2020, Jack et al., 2010). Thus, to mitigate these disparities, it is imperative to involve Black men in diabetes research and collaborate on the development of tailored digital health interventions.

Digital health technologies have the potential to revolutionize diabetes management for Black men, but currently, there is a dearth of information to inform their development and implementation. To effectively address the racial disparities that exist in diabetes outcomes, it is essential to engage Black men with diabetes as active participants in research to identify their unique barriers and facilitators, which can then be used to create tailored digital health solutions and can ultimately lead to more equitable healthcare outcomes.

2.2 Methods

Study Design, Sample, and Setting

A qualitative descriptive design was utilized to gain a deeper understanding of participants' perspectives, a technique appropriate to use for insufficiently studied issues (Sandelowski, 2010). Such an approach is necessary and appropriate to find the who, what, and where of events or experiences and elicit participant perspectives on a poorly understood topic (Kim et al, 2017). As little is known about Black men's personal motives, individual subtleties, or specific criteria that could potentially influence their use of a digital application for efficient self-management of diabetes, it was determined that a qualitative descriptive study design would be most beneficial.

The sample population comprised self-identified African American or Black men, who were at least 18 years old, residing in the United States, with a diagnosis of Type 1 or Type 2 diabetes. To be eligible, participants had to own a smartphone and be able to read and speak English at a functional level. The exclusion criterion for this study was not having been instructed by a healthcare practitioner to check blood glucose levels at least once per week.

Participants were recruited through convenience methods, recruiting participants by posting an IRB approved flyer on social media and community-

based websites such as LinkedIn, Facebook, Instagram, and Craigslist. Each participant was compensated \$45 via a digital gift card for their time.

Ethical Considerations

Duke Health Institutional Review Board (IRB) provided study approval. Informed written consent was obtained after participants were provided with information about the study's purpose, an overview of participation, and what they could expect throughout the process. Participants were advised of the voluntary nature of the study, the risks and benefits associated with participation, and the methods by which confidentiality would be maintained (Manti & Licari, 2018).

2.3 Data Collection

Five members constituted the research team. The lead author and two coauthors were African American; the other two coauthors were Latina and Caucasian, respectively. The second author is a qualitative expert. Semi-structured interviews were conducted between April and December 2021 by the lead investigator, who was trained in qualitative research methods and whose social and racial identification closely matched the cultural background of the participants. A semi-structured interview guide was created and piloted prior to use with participants. Interviews were conducted via Zoom online video

conferencing (San Jose, CA). Interview length ranged from 25 to 95 (average of 60) minutes, and the recorded interviews were then transcribed. The researcher took notes regarding general impressions and early evaluations of each interview. Data on demographic variables such as race, ethnicity, gender, age, educational attainment, and current health insurance coverage were collected prior to the interview via an online survey.

2.4 Data Analysis

Conventional content analysis involves three phases, preparation, organization, and reporting, as identified by Elo and Kyngas (2008). The preparation phase began with the removal of personal identifiers from the transcripts and assigning study ID numbers to each. Thereafter, the transcripts were uploaded into NVivo software (QSR International, 2012) to facilitate the analysis. In this phase, the first author embarked on data exploration, which included reading and re-reading all transcripts to develop a familiarity with the content and establish a general sense of emergent topics (Graneheim & Lundman, 2004; Miles et al., 1994). Throughout the data exploration process, memos were drafted to document impressions, thoughts, initial assessments, and analytical procedures.

The organization phase of the traditional content analysis method began with the identification of meaning units (Hsieh & Shannon, 2005). This entailed highlighting exact phrases or sentences that best captured the critical concepts or ideas surrounding patient-generated health data and diabetes management. To make sense of the data, these meaning units were labeled with codes that described their contents, and then sorted into categories based on similarities (Hsieh & Shannon, 2005). The categories were further grouped into higher order themes, in accordance with qualitative recommendations (Elo & Kyngas, 2008). Finally, quotations were extracted from the data to exemplify each code and category and compiled in a codebook.

The coding process for this study began with the first author coding each interview independently. The completed codes were then reviewed with corresponding data by the second author for coding confirmation. Next, the second author reviewed 30% of the data independently, in accordance with established practices (Morse, 2015). The authors then engaged in discussions to achieve consensus in coding and categorization, resolving any discrepancies that arose. Data analysis was continued until saturation was reached, indicating that no new or relevant information could be identified (Morse, 2015). The detailed findings are reported below.

Rigor

Maintaining scientific rigor in data collection and analysis required us to adhere to the four principles of trustworthiness: confirmability, dependability, credibility, and transferability (Lincoln & Guba, 1985; Cope, 2014; Morse, 2015). Confirmability was ensured by providing rich and thorough descriptions of the study findings, along with quote exemplars (Elo & Kyngas, 2008). Dependability was maintained by using a codebook and coding checks to ensure consistency in study processes across researchers and settings (Elo & Kyngas, 2008; Hsieh & Shannon, 2005). Any coding disagreements were resolved through discussion. Credibility was ensured by providing detailed descriptions of the phenomenon, supported by exemplar quotes (Elo & Kyngas, 2008; Hsieh & Shannon, 2005). Lastly, we enhanced the transferability of our research findings by providing rich descriptions in the data to facilitate comparisons with other contexts (Elo & Kyngas, 2008; Hsieh & Shannon, 2005). The strategies are listed in detail in Table 2.

Table 2: Scientific Rigor Strategies

Principle of Trustworthiness	Strategy Used
Credibility	Credibility was established by combining elaborate, thorough descriptions of the phenomenon with illustrative quotations.
Confirmability	Confirmability was achieved through the maintenance of an audit trail and the provision of rich, detailed descriptions of the study's findings with quotation exemplars describing the needed app components.
Dependability	A codebook and coding checks were used to guarantee that the study procedures were uniform between researchers and venues.
Transferability	Detailed data descriptions boosted the transferability of the research findings by facilitating comparisons with various contexts.

2.5 Results

Participants ($N = 20$) were Black or African American men with a mean age of 44, of whom 60% had been diagnosed with Type 1 diabetes and the remaining 40% with Type 2 diabetes. Twenty-two percent had a high school diploma or equivalent, 20% had some college, 36% had a bachelor's degree, and 22% had a master's degree (See Table 3).

Table 3: Participant Demographics

Demographic Items	<i>M</i>	<i>Range</i>
Age	44	(25-70)
	<i>n</i>	<i>%</i>
Diabetes Type		
Type 1	12	60%
Type 2	8	40%
Education		
High School Diploma or GED	5	25%
Some College	4	20%
Bachelor's Degree	7	35%
Graduate Degree	4	20%
Income		
Prefer Not to Say	5	25%
Less than \$25,000	2	10%
\$25,000 - \$49,999	3	15%
\$50,000 - \$99,999	7	35%
\$100,000 - \$149,999	1	5%
\$150,000 - \$199,999	1	5%
More than \$200,000	1	5%

n = 20

The analysis revealed that three major themes emerged from the data: (a) usefulness of technology, (b) addressing accessibility, (c) support from provider. Themes were divided into subthemes to provide a detailed overview of the topic being studied (see Figure 1).

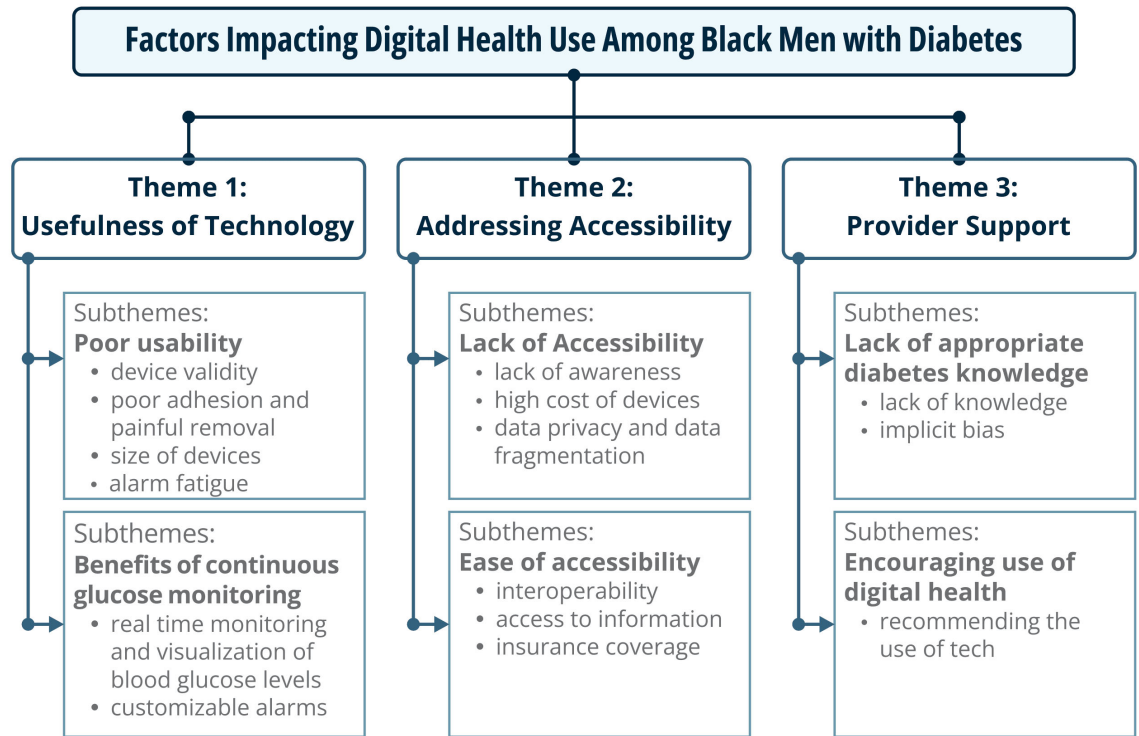


Figure 1: Factors Impacting use of Health Technology to Manage Diabetes among Black Men

Usefulness of Technology

The theme usefulness of technology describes the preference for continuous glucose monitoring as well as challenges with using mobile health apps as either barriers or facilitators for self-management of diabetes. The subthemes included a) benefits of continuous glucose monitoring and b) challenges with usability.

Challenges with Usability

The attributes of diabetes technologies that limited its use among the participants included device validity, poor adhesion and painful removal, size of

devices, and alarm fatigue. Concerns about device validity arose when the participants found that the CGM readings were often inconsistent with finger stick blood tests. Not having an accurate picture of the blood glucose levels made the participants feel insecure and sometimes resulted in treatment errors. One participant noted,

I think a lot of times these devices may not be as accurate as they could be, and that can be frustrating because if CGM says that [blood glucose is] 150, and you check it and it's 200 and going up, that can be frustrating. That can be detrimental because you never know what situation you can be in. (Participant 7)

Such experiences affected the participants' level of trust and reliance on CGM readings, often leading them to perform confirmatory fingerstick tests. Having to use CGM and fingerstick tests was a frustrating experience. As one participant expressed,

When I started using FreeStyle Libre, my readings were super high and then . . . super low... I was giving myself extra medicine for the wrong blood sugars, and I was pricking my finger. I'm like, "What's the point of me having this CGM?" I keep pricking my finger. There's no point. (Participant 8)

As a cautionary measure, the participants made purchasing decisions about diabetes devices based on product reviews and other people's experiences with the apps. One participant noted, "There's not a whole lot out there that's like straight up 100% accurate . . . so you just really have to do your homework and read reviews and ask . . . other people that may be using it." (Participant 14)

The second usability barrier that participants discussed was poor adhesion and painful removal of the continuous glucose monitoring device. The participants noted that they experienced challenges with keeping the CGM in place because it came off easily during everyday activities such as "leaning on a couch," "working out," "bumping into a door," or coming into contact with water. Participants described these experiences as "frustrating," "horrifying," and "annoying" because once dislodged, the CGM could not be put back in place, and one had to restart the glucose monitoring process. To cope, the participants invested in super adhesives to keep the sensors in place. One participant said,

The one thing I don't like about the FreeStyle is that it goes on the back of your upper arm, which is fine and everything until you bump into the door, and it rips off, and you can't put it back. So, when I put it on, I

actually have this other clear sticker thing that . . . goes over it, so it keeps it in place for that 14 days. (Participant 6)

The pain associated with removing the continuous glucose monitoring sensors from the back of the upper arm was uncomfortable and discouraged some participants from using certain brands. The participants preferred sensors like the G6 that provided options for a less “invasive” site of application.

The bad part is taking the thing off. It’s like ripping a band-aid off . . . pulling every little fricking hair from around your arm, and so it’s very uncomfortable. So I would want [the sensor] to be in a place that’s a lot less invasive, and I think that’s the reason why the G6 interests me so much, because it goes on your belly. (Participant 19)

Participants experienced a buildup of scar tissue from the CGM, insulin pump, and some smartwatch bands. One participant shared that “the scar tissue that builds up from insulin pumps and CGMs sucks.” (Participant 9) Others noted that scarring from the CGM was a concern: “From what I’ve heard, it can cause scarring.” (Participant 4)

The third usability barrier that participants shared was concern about the size of the continuous glucose monitoring device. Some participants felt insecure because the devices were visible and drew attention from peers. They were also

concerned that they would be seen as different. One participant explained, “I was just creeped out by the CGM because I already had someone call me and tell me like, ‘Oh my gosh, you’re like a cyborg because you have that huge tech equipment attached to you.’ I was like, ‘I’m a cyborg? Oh no, no I’m not.’”

(Participant 17)

Although the general feeling was that manufacturers should design smaller devices to make them less noticeable, participants with larger body sizes felt that the insulin pump was already too small to hold adequate insulin for their treatment needs and were concerned about constantly refilling the pump. As one participant explained,

I use a lot of insulin. I’m overweight, so I use quite a bit, and . . . having to change a reservoir literally in the middle of the day to keep getting insulin . . . it’s not something I really want to fuss with right now. (Participant 13)

Some participants were hesitant to use the CGM and the insulin pump because the devices were attached to the body all the time; although they acknowledged that the devices did not interfere with their day-to-day activities, they found the tubing and the risk of kinks too cumbersome. Comments included “One of the hesitations of Dexcom, it’s just there’s literally something plugged into you at all times. It doesn’t get in the way, but . . . I don’t want to risk it.” (Participant 4)

“[The insulin pump] is a big contraption, like the hose and the kinks. . . I just

don't know if I'm ready for it and having something give me insulin.”

(Participant 13)

The fourth barrier participants discussed was alarm fatigue. Participants found frequent and/or false alarms irritating and stressful. The alerts were not always necessary as some participants could instinctively feel when their blood glucose levels were either low or high. However, the on-and-off alarm function was out of their control.

For the most part, you can feel how your body is. You can feel when it's low, feel when it's high, for the most part. So, the alerts . . . it's like you telling me what I already know, and I can't turn you off, and it's no way to get rid of you, so I wish you'd just stop. (Participant 9)

Benefits of Continuous Glucose Monitoring

The subtheme “benefits of glucose monitoring,” participants described the belief that continuous glucose monitoring (CGM) devices were superior to glucose meters. They discussed the improved features of CGMs that motivated them to adopt CGMs over glucose meters, including real-time monitoring and visualization of blood glucose levels and customizable alarms.

The first facilitator participants shared to using a CGM was real-time monitoring and visualization of blood glucose levels. Continuous monitoring of

blood glucose levels, the automatic logging feature, and visualization of patterns and trends in blood glucose levels were some of the key features of CGMs that encouraged the study participants to switch from glucose meters. Glucose meters measured blood glucose levels at a single moment in time, making participants “feel . . . blind to what was going on.” (Participant 9) Conversely, CGMs monitored blood glucose levels continuously, enabling the participants to gain a clear picture at any particular time and between different data points. One participant noted,

Your ‘time in range’ matters more than what’s your blood glucose at any given moment, because if I’m checking my blood sugar and . . . I’m a hundred, and . . . I’m a hundred two hours after [that], . . . that’s great, but what’s going on between [those] two hours? Ultimately, you want to be consistent. (Participant 7)

When using glucose meters, participants kept a manual record of their blood glucose levels. Manual logging was a taxing and time-consuming process which provided limited information. On the other hand, CGM automatically created a record of blood glucose levels. This reduced the amount of work and time spent on taking measurements and provided detailed information useful for making informed decisions about self-management practices.

The CGM lasts for 14 days, so you can get that data and make better adjustments to your lifestyle. That's just been a lot simpler than pricking my finger and writing it down. . . . Some days I work 9 to 11 hours . . . I don't really have time to do all of that, so I kind of need those readings to be instant to be able to go through my day and have the least amount of friction as possible. (Participant 12)

CGM presented data in simple charts and graphs, allowing participants to observe trends in blood glucose with physical activity, diet, emotions, and sleep, and helped them to make necessary modifications to keep their blood glucose within the target range.

When I'm exercising, I can check my glucose levels right in the instant. . . . So it's helped [me] to make adjustments to my workout. Like some workouts, my glucose levels spike, and then some workouts, they go down. So, I have to make adjustments for that. (Participant 12)

I know that when I wake up in the morning, my glucose levels are usually high... making proper adjustments at night, maybe not eating so much carbs before bed, or stop eating at a certain time before bed has helped with that. (Participant 8)

One participant commented, "If you're mad or if something pisses you off really, really quickly, your blood sugar will shoot up, like instantly. That's kind of just how it happens." (Participant 9)

Analysis of the patterns and trends provided useful insights that enabled the participants to predict insulin dosage requirements and behavior modification in similar scenarios.

You get to where you have all of this data coming at you, [and] you're able to apply that data in different situations. So, for instance, I know after I eat a pizza, two hours later my blood sugar's going to start rising. So, I know the next time I eat pizza to do an extra bolus, maybe like an hour or two later. (Participant 19)

The participants strongly felt that continuously monitoring blood glucose and identifying the contributing factors using data from the CGM contributed to improved self-management practices and, eventually, to improved clinical outcomes. One participant explained,

My A1c is going down four or five points solely because of the CGM. Like it's not anything I've done personally. My diet's still the same, but because of the Dexcom, my A1c is like 6.7 now. It used to be like a nine. (Participant 9)

The last facilitator that participants mentioned was customizable alarms. Customizable built-in alarms helped the participants become aware of critical blood glucose levels and prompted them to make the necessary insulin dosage adjustments. Knowing that they would receive alerts provided a sense of security, particularly when sleeping at night.

There's a lot of alarms before you get too low. . . . I'm a heavy sleeper. At times it woke me up, and I was able to catch it. So that eliminates a lot of fear that I had with sleeping at night with Type I diabetes because I was on the side of caution before, you know, [by] having pump and CGM.

(Participant 1)

The alarm feature also helped some participants to set a regular exercise schedule.

The alarm tells me to get up and walk or get up and stretch...I have a set where it tells me every hour to get up and walk and stretch . . . and that helps me get out of the mode of just being sedentary and just sitting around. So, that has been very beneficial. (Participant 5)

Addressing Accessibility

The theme addressing accessibility describes participants' what made it easier or harder for participants to access and use digital health to manage their

diabetes. The subthemes included a) accessibility issues and b) ease of accessibility.

Lack of Accessibility

The subtheme “lack of accessibility” describes the issues participants had around using digital health to manage their diabetes including lack of awareness and high cost of devices. Participants also discussed concerns around data privacy and data fragmentation.

Participants discussed lack of awareness, which pertains to a lack of up-to-date information about diabetes technology options from healthcare providers and device manufacturing companies which delayed participants’ adoption of the technology and made it challenging for them to set up and use the devices. Most of the participants reported that their healthcare providers did not provide them with information or recommendations for credible information sources about diabetes technology. Their first encounter with the technology was through interaction with other users, years after their initial diagnosis.

I went to the diabetic camp as a counselor, and I’m walking around. That was my first time seeing somebody with a CGM, and I’m asking them, “Hey, what is that like?” At that point, I’ve had diabetes for like 15 years, and I didn’t really know what exactly it was. (Participant 9)

The providers did not conduct product demonstrations to guide patients on how to handle, read and interpret readings on devices, nor did they provide recommendations for reliable sources of information. One participant shared that “When I was growing up, doctors would always say, ‘Get an insulin pump,’ but no doctor ever showed me the insulin pump.” (Participant 8)

Participants found that device manufacturing websites lacked useful information on how to set up and use the devices. The pages were focused on advertising and selling:

Company pages are just trying to sell you stuff. How I know is that you tell me certain things will happen, and then [they don’t]. . . . For example, I wanted to buy a smartwatch. I got home, and then it won’t work with the Dexcom app. . . . I kinda lost trust in them a little bit. (Participant 17)

Some participants struggled to obtain insurance due to a lack of information. The lack of health insurance limited access to diabetes devices. One participant explained,

I’m self-employed, so I don’t have insurance like an employer per se, so I had to figure out how to navigate insurance through the marketplace. . . . If I would have known what I know now back then, it would have been

an easier process, but you don't learn that in school . . . you kind of just learn that through living life. (Participant 9)

The second usability barrier participants discussed was the high cost of devices.

The high cost of CGMs prevented the participants from using the devices.

Uninsured and underinsured participants needed to invest between \$75 and \$600 every two weeks depending on the CGM brand. They incurred additional costs in purchasing adhesive stickers and replacing devices that weren't compatible with their phones. Some participants felt that these out-of-pocket expenses were "unsustainable," particularly for young men in their early 20s and 30s.

I was paying for CGM out-of-pocket for a little bit . . . at the time I was 30 years old, striving to set aside money for a house and really trying to get a foothold into my future for success, and . . . we can't spend \$500 every two weeks for a CGM, like that's outlandish . . . so I had to quit CGM for a while, and I was only doing pump. (Participant 11)

Some participants recommended the development of "reusable," "renewable," and cost-effective devices that would be accessible to all, regardless of social economic status. As one participant explained, "The biggest thing is making it reusable, . . . something that could be put in place without having to

constantly change it out, . . . something renewable and cost-effective, so that from the rich[est] to the poorest of us, [it] can improve our lives.” (Participant 2)

A few participants suggested that improved access to information on how to obtain insurance could increase access to CGM devices. One participant commented, “I had to figure out how to navigate . . . insurance through the marketplace and healthcare.gov, and all this other stuff... If I would have known what I know now back then, it would have been an easier process.” (Participant 9)

Participants discussed their concerns with data privacy and safety, and data fragmentation. The participants expressed concerns over the security of systems that transmit patient data to healthcare providers and insurance companies both internally (e.g., disgruntled employees who might have the potential to misuse the data) and externally (e.g., attacks by hackers who might easily bypass security protocols to obtain and misuse personal medical information). Participants seemed to accept that security breaches were inevitable and that there was little that could be done to mitigate the consequences. As one participant noted,

The security of systems really can't be guaranteed. And medical information is one of the most sensitive types of information because it

adds those personally identifiable things that you really can't change. . . .

[If] data gets either viewed or copied, then there's nothing really that you can do [when a] disgruntled employee goes and does something with the data. There's nothing that you can do about it. (Participant 2)

Participants felt that data fragmentation due to multiple data platforms interfered with comprehensive patient care. Having to go to different portals to access health information increased the chance of omitting information, making it difficult to develop a comprehensive picture of the patient's condition and introducing a delay in retrieving information.

It presents some challenges when you were going, let's say from your primary to your cardiologist. . . . [G]enerally, they should be sending records, but that's not always the case, so you may have lag, or it's not in the system, or they seem to have difficulty . . . pulling all the data together to give you a comprehensive picture. (Participant 1)

Ease of Accessibility

The subtheme "ease of accessibility" described factors that were perceived to make it easier for patients to access digital health to manage their diabetes.

Factors that contributed to ease of accessibility included interoperability, access to information about diabetes technologies and insurance coverage.

The participants found it easy and convenient to check blood glucose readings from a smartphone while at their workplaces, which they described as interoperability. They expressed that because they had their phones with them “fairly often,” they could check the levels frequently and discreetly.

It’s really easy for me to pick up my phone and just go, and I can see what my sugar levels were at that particular point in time . . . plus I can check it like 20 times a day, and it’s not 20 strips, you know. It is just extremely convenient. (Participant 18)

I don’t have to reach out and get my pump out and anybody be like, “Oh, what’s that? What’s going on?” With my phone, I can just pull up my APP and see my blood sugar and see how the trend is going. (Participant 11)

The ability of the devices to interact provided an opportunity for enhanced features. For instance, Participant 8 used the high and audible phone alarms in place of the low CGM receiver alerts, commenting, “You can hear your phone ring whenever. Cause like sometimes, the receiver is super low beeping, but the phone will overpower all the ringers.”

CGMs enabled participants to share blood glucose data with healthcare providers, close family, and friends through the share button or by downloading and sending the data via email. Healthcare providers could review the shared

information ahead of an appointment, allowing them to communicate with participants from an informed perspective and save time that would have otherwise been spent reviewing the numbers. As one participant explained,

The doctor can see your 90 days of Dexcom readings before you even walk into the office, so it really does cut down on time as far as the conversation about her just seeing the numbers from a Quest report or an A1c. It speeds [the appointment] up a little bit. (Participant 13)

In between face-to-face appointments, healthcare providers were able to remotely monitor trends in the participant's blood glucose levels, diet, physical activity, and sleep. This information helped clinicians support the participants in making informed decisions about managing blood glucose levels. A participant explained,

All your numbers go directly to them [practitioners]. They see your glucose levels, your sleep, how much you're exercising . . . so if they see you are super high, your coach will hit you up and pretty much try to get you in remission. (Participant 10)

The participants felt that the ability of family members and friends to remotely monitor trends in their blood glucose levels provided an added layer of support. Such followers kept them aware of critical blood glucose levels and were a

source of encouragement. As one participant expressed, “It’s cool to have people to be like, ‘Oh, your sugars are running low,’ because sometimes, I don’t catch it. Or like, ‘Hey “participant 17”, congratulations. Your sugars are in range, good job.’” (Participant 17)

Participants discussed “access to information”, which pertains to the availability, sources, and use of information about diabetes technologies. Participants felt that access to information increased their likelihood of adopting diabetes technology. They identified three important sources of information: social media, support groups, and healthcare providers. Social media applications such as Instagram provided platforms on which individuals, groups, and professional organizations could create diabetes-focused online communities, thus allowing connection and interaction among people with similar experiences. These communities provided spaces in which people shared knowledge and described experiences with diabetes technologies and lifestyle modifications for better diabetes management which influenced some participants to adopt diabetes management technology. One participant commented, “When I started joining the communities, I want to say five years ago, . . . specifically looking for diabetics online, that’s when I found out about Dexcom” (Participant 3). Another stated, “When I would get results with

something, or I would get new technology, I would immediately post and tag whoever, whether it would be Dexcom, Omnipod, Ozempic, Trulicity.”

(Participant 10)

Participants considered the diabetes online communities to be a rich source of information, particularly for Black men who might be reluctant to seek help in a culture that perceives requesting assistance as a sign of weakness or vulnerability. One participant explained,

Some Black males would reach out and want to have information and stuff... I know, as like a Black male, we have this masculine image that we're brought up with, so it's kind of hard to ask for help or show any kind of weakness... So the fact that I share [my experiences with diabetes] gives them space to come to me and be able to talk about those things.

(Participant 12)

Some participants felt that information about diabetes technologies was readily available, but people had to look for it proactively, and healthcare providers had to be willing to provide it to their patients.

The FreeStyle Libre, you can get it by prescription at most pharmacies, and it's not that expensive . . . these are the things that a lot of people don't know unless they get a good endocrinologist or primary care

[provider] that tells them this, or if they have the fortitude to get online and look for information, like on social media. (Participant 14)

Insurance coverage enabled participants to access CGM devices easily: “The process was easy for me, like I said, once insurance says they cover you, I mean it’s easier than that. It’s just a matter of being offered it.” (Participant 10) There were opportunities, too, for individuals who were underinsured and uninsured. For instance, some participants were able to access CGM devices by participating in diabetes device clinical trial programs offered by insurance companies or programs for the underinsured offered by device manufacturing companies.

Participants explained,

Another thing what people need to understand is, no matter what your insurance is, they always have programs. Like I’m in the Level Two program, and through them, my CGM is free now because I’m pretty much a guinea pig for them. (Participant 10)

Medtronic now has a pathway program that allows access for people that are underinsured, and it allows them to basically pay a price as if, you know, they have insurance, and it allows access to people by Medicaid and Medicare, and it’s given people access [to devices]. (Participant 3)

Support from Providers

The theme support from providers described how providers could encourage or discourage use of digital health to manage diabetes among Black men. The subthemes included a) lack of appropriate diabetes knowledge and b). encouraging use of digital health

Lack of Appropriate Diabetes Knowledge

This subtheme “lack of appropriate diabetes knowledge” describes how certain provider related factors perceived by Black men with diabetes such as lack of knowledge of digital health options, implicit bias against Black men, and a “wait-and-see” attitude serve as a barrier to digital health use among Black men with diabetes. Participants were not offered diabetes technology at the earliest opportunity, and they attributed this to the health care provider’s implicit bias, wait-and-see attitude, lack of knowledge, and desire for financial gain. According to the participants’ experiences, healthcare providers made unilateral diabetes treatment decisions based on skin color and their perception of the participant’s social economic status.

This thing (CGM) been out for over five years, and I just heard about it a year and a half ago, so . . . were doctors [thinking], “Hey, like, let’s get him what we think he can afford [?]” But I will highly say, based off the color

[of] your skin, people . . . treat you the way they think you should be treated... you know doctors thinking I was poor just because I'm Black –

Participant 8

The participants felt that some practitioners were skeptical about new technology, possibly due to past experiences with failed technology, and preferred to wait and see whether the diabetes technology would be effective before recommending it. One participant shared, “Some doctors want to see where it lands, I guess is the best way to say it, before they recommend it to everyone.” (Participant 3)

Some participants felt that older doctors did not offer diabetes technology due to a lack of knowledge and suggested reeducation programs for them, but as one participant noted,

The doctors that I was first diagnosed in ERs [by] were older, and they just didn't inform me of what the best care for me was, and so it's going to be hard to train those doctors, to reeducate them, because they don't have time. (Participant 11)

The participants felt that the delay and/or failure to offer diabetes technology denied them the opportunity to choose the most appropriate treatment option. One participant summed up the situation neatly: “You're going to have people

that prefer one thing over the other, but it's finding that right mix of technology and opportunity and knowledge and education that really helps them live a normal life." (Participant 3)

Encouraging use of digital health

The subtheme, "encouraging use of digital health" describes how recommendation of digital health use by providers serves as a facilitator to digital health use among Black men with diabetes. The participants felt that the adoption and use of diabetes devices by Black men was highly influenced by healthcare providers who embraced and recommended health technology. One participant shared, "My endo is really the one that's responsible for all my technology needs and everything that I have. So, she was the one that, every time you come to the office, she got something behind her, whether it's an Omnipod, a new insulin pen, [or] something." (Participant 10)

2.6 Discussion

This study sought to explore the facilitators and barriers to and perspectives on the use of digital health for self-management by Black men with diabetes. Our analysis revealed that three major themes emerged from the data: (a) usefulness of technology, (b) addressing accessibility, (c) support from

provider. Participants found continuous glucose monitoring to be superior to glucose meters due to its real-time monitoring and customizable alarms, but they also encountered barriers to using CGMs such as questionable device validity, poor adhesion, and alarm fatigue. Participants faced challenges using digital health for diabetes management due to the high cost of devices, lack of awareness, and concerns around data privacy and fragmentation. Also, participants felt that healthcare providers who recommended digital health technologies played a key role in facilitating the adoption and use of diabetes devices or apps among Black men.

To our knowledge, this is the first study to utilize a qualitative descriptive approach to evaluate the barriers and facilitators to digital health usage specifically among Black men with diabetes. Consistent with previous research findings, app features perceived as helpful were logging blood sugar readings, visual representation of trends in the form of graphs, data sharing functions, tracking self-management behaviors, customizable alarms, and compatibility with other technology such as mobile phones (Jeffrey, et al. 2019; Olivencia, et al. 2022; Barber-Gumbs, et al., 2021; Yoon, et al., 2022). This study also found that a recommendation from a healthcare provider was a facilitator of the use of health technology. Jeffrey et al. (2019) reported that a potential facilitator of the use of

mobile phone applications for self-management of type-II diabetes was a recommendation from a healthcare professional; however, most of the studies reviewed in our study reported that providers were not actively recommending health technology. In a study by Jeffrey et al. (2019), only 2 out of 30 participants had received an app recommendation from a healthcare professional. According to health care providers participating in a recent study by Bults et al. (2021), one reason for not recommending apps was lack of knowledge about their functions and availability on the market.

A frequently reported barrier to use was lack of awareness among both patients and clinicians. Our study found that most participants were unaware of available diabetes technology. In a previous study, participants wanted to receive information from providers because they perceived them to be a reliable source (Jeffrey, et al., 2019); however, most participants in our study reported that providers did not talk about or support the use of the apps. Alarms, alerts, or reminders were considered both facilitators and barriers. Participants found them useful for alerting them about critical blood glucose events, helping them to adhere to medical regimens, and scheduling activities and appointments; however, too many reminders about medication, food intake, and physical

exercise were annoying, and the participants felt that the reminders should be personalized and customizable (Yoon, et al., 2022).

Challenges with learning how to use devices and interpret data interfered with participants' ability to estimate treatment needs and develop effective behavioral interventions. This was consistent with previous findings that participants found the apps difficult to navigate and not user-friendly (Jeffrey, et al., 2019).

Future research should aim to explore effective strategies to address the unique needs of Black men utilizing digital health technologies to manage their diabetes. For example, as both providers and patients need better awareness of available options, perhaps health systems or insurance companies should employ digital health navigators whose job it is to stay abreast of apps, devices, and other updates in order to help match patients to tools that will meet their needs and support them. Furthermore, clinical research should aim to investigate the clinical efficacy of digital health tools for diabetes management among Black with diabetes specifically.

Strengths and Limitations

Like most qualitative studies, this study involved a small sample size, so the findings may not be representative of the views of all Black men with

diabetes. To overcome this limitation and obtain multiple perspectives, we purposively recruited a diverse range of participants. It is important to note that due to the COVID-19 pandemic restriction for in-person meetings, all interviews were conducted online via Zoom (San Jose, CA), an online conferencing platform, which may have resulted in the exclusion of participants with low digital literacy.

2.7 Conclusion

This study provides important insights into the barriers to and facilitators of utilizing digital health for diabetes self-management among Black men with diabetes, and their related perspectives. Our study highlights the importance of incorporating features perceived as likely to increase adoption and use of health technology to improve diabetes self-management, improving access to information and insurance coverage, and paying attention to the role of healthcare providers in promoting and supporting the use of health technology. Our findings can inform the development of future digital health interventions for Black men that help to address health inequities with diabetes management. The outcomes of this research can aid in the creation of future digital health interventions specifically targeted at Black men with diabetes, however there is a substantial need for further research in this area with larger sample sizes.

3 Desired mHealth App Features to Facilitate Self-Management among Black Men with Diabetes: A Qualitative Study

3.1 Introduction

From 1980 to 2020, the prevalence of diabetes among Black men in the United States (U.S.) increased by more than 160%, reaching epidemic proportions (HHS.gov, 2021; CDC, 2022; Hurt et al., 2020). Diabetes is currently the seventh leading cause of death in the US but the sixth leading cause of death among U.S. Black men (ADA, 2022; CDC, 2022). In fact, Black men are twice as likely as non-Hispanic white men to be diagnosed with type 2 diabetes and experience diabetes-related complications (Hawkins et al., 2022). According to Hawkins et al. (2022), Black men have lower glycemic control and are more likely to die from diabetes-related complications at an earlier age than their white counterparts. Due to their diabetes diagnoses, Black males are twice as likely to die and three times as likely to be hospitalized and have end-stage renal disease (American Heart Association, 2022) compared to White men. These statistics reveal a need to identify strategies to eliminate health disparities among Black men with diabetes.

Effective self-management involves multiple measures including modifying one's diet to reduce carbohydrate intake and increase consumption of low-glycemic foods, increasing physical activity, monitoring blood glucose levels

at appropriate intervals, taking prescribed medication(s), and attending all recommended follow-up care appointments with health providers. Self-management necessitates risk reduction, problem solving, and healthy coping in addition to behavioral adjustments (Adu et al., 2019). Multiple studies demonstrate the positive effects of diabetic self-care on an individual's ability to make better food and physical activity choices. Effective patient education, in particular, has been linked to increased physical activity, smoking cessation, adherence to dietary recommendations, proper foot care, decreased serum hemoglobin A1C (HbA1c) levels, body mass index reduction, serum cholesterol improvements, improved quality of life, and increased self-efficacy (Azami et al., 2018; Bekele et al., 2021; Brunisholz et al., 2014; Carmienke et al., 2020; Hailu et al., 2019; Kargar Jahromi et al., 2014; Marincic et al., 2019; Qayyum et al., 2010; Rusdiana et al., 2018; Yuan et al., 2014; Zheng et al., 2019). The American Diabetes Association advocates that following a diagnosis of diabetes, it is recommended that providers engage patients in self-management education and support consisting of behavioral, informational, psychosocial, or clinical strategies. According to Powers et al. (2016), education and support programs should be designed to address the patient's health beliefs, cultural background, physical ability, emotional situation, family involvement, financial status, past

medical history, health literacy, and numeracy, as well as other factors that impact the individual's capacity to meet the challenges of self-management.

However, the literature suggests Black men with diabetes struggle with self-management (Jack et al., 2010; Hawkins et al., 2022). Black men face more challenges in effectively managing diabetes than non-Hispanic whites and even Black women, due to various factors such as unequal healthcare access, communication barriers, low health literacy, gender-related expectations, and skepticism towards the medical system (Chlebowy et al., 2010, 2013; Ricci-Cabello et al., 2013). These challenges are compounded by the absence of culturally tailored diabetes self-management resources, making it challenging for Black men to manage their diabetes. However, digital health tools have the potential to overcome some of these obstacles by providing real-time access to health data, customized feedback, and educational resources (American Diabetes Association, 2019).

Digital health, namely through mobile applications, has gained popularity for the management of diabetes and has shown a wide spectrum of self-management success; various studies have demonstrated results such as decreased HbA1c levels, improved adherence to drug regimens, decreased weight, decreased blood pressure, and increased physical activity (Ehrmann et

al., 2022). Digital health tools can have positive impacts, including raising patients' awareness of their own health status, teaching them to track their health data, and assisting them to use self-care behaviors (Villalobos et al., 2020). According to Shan et al. (2019), the goals and components of contemporary digital health interventions that target diabetes are broad and include insulin management applications, wearable blood glucose meters, automated text messaging, health diaries, and virtual health coaching. In addition to aiding in the monitoring of glucose levels, these devices are extremely valuable for calculating medicine dosages, monitoring nutrition and exercise, and providing educational opportunities. In addition, systematic evaluations have found a correlation between the usage of digital health applications and improved diabetes control; their capacity to improve self-management is strong (Ali et al., 2016; Byambasuren et al., 2018; Dugas et al., 2020; Fortuin et al., 2016; Kebede & Pischke, 2019; Mao et al., 2020; Marcolino et al., 2018).

To boost the acceptability of digital health applications, adherence to care, and the overall efficacy of nutritional and other interventions, it has been suggested that the application's features should be customized to the user's cultural background and values. If the application is not viewed as culturally appropriate or beneficial, it will not be effective at increasing self-care

management practices (Donnelly, 2020); therefore, it is essential to involve end-users in the creation of appropriate digital health features to generate characteristics that sustain motivation for continuing use and self-management engagement. User-centered designs have demonstrated promise for enhancing users' perceptions of application effectiveness and assisting them to engage in long-term behavioral change (Bonet Olivencia et al., 2021); however, few of these studies have addressed the needs and expectations of Black men with diabetes. The consequences of diabetes disproportionately affect men as they often have a greater need for care and less access to culturally congruent resources to support their self-management (Hawkins et al., 2020). Although digital health holds great promise to facilitate diabetes self-management and care, data are lacking to inform the development of digital health solutions tailored to Black men with diabetes. One small study demonstrated that if mobile health technology is integrated with physical activity and culturally-appropriate discussions and care, the self-management of diabetes in Black men can be improved (Carthron et al., 2021). Further, because Black men are underrepresented in diabetes related research, limited data has captured their perspectives to inform development and testing of diabetes related interventions or digital health technologies. Due to this critical lack of knowledge, it is likely that the U.S. care system has not

developed inclusive strategies to adequately serve this important population; these culturally inclusive strategies are imperative to advance scientific knowledge related to racial/ethnic health and healthcare inequities and reduce existing diabetes related disparities. It is important to obtain further input from Black men with diabetes, as key stakeholders in research, so that applications tailored to their unique needs can be developed and tested to help improve self-management and mitigate existing racial disparities in diabetes outcomes. To address this gap, this study aimed to investigate desired design requirements for a diabetes self-management app among Black men living with diabetes.

3.2 Methods

Study Design, Sample and Setting

This qualitative, descriptive study was conducted from April 2021 - December 2021.

A commonly proposed rationale for using descriptive approaches is to provide direct descriptions of perceptions or experiences, especially in relation to subject areas about which little is known (Sandelowski, 2010). This approach was specifically chosen to allow the data from individual interviews to provide an enriched, in-depth understanding of the requirements for a diabetes self-management application for Black Men (Creswell & Plano-Clark, 2017).

Eligible participants met the following inclusion criteria: (a) self-identified as African American or Black male living in the US, (b) ≥ 18 years old, (c) able to speak and read English (self-report), (d) diagnosed with Type 1 or Type 2 diabetes, (e) owned a smartphone with internet access, and (f) self-reported that their primary care provider recommended that they monitor their blood glucose at least once a week. Subjects at various stages of diabetes with oral and/or injectable treatment regimens were included.

Participants were recruited through a mix of convenience and snowball sampling via online advertisements (e.g., Craigslist) and posts on the professional and social networks of the study principal investigator (PI) (e.g. LinkedIn, Facebook, and Instagram) using study flyers geared towards Black men living with diabetes within the United States. Participants were compensated with e-gift cards in the amount of \$45 per one-time interview.

Ethical Considerations

Duke Health Institutional Review Board (IRB) approval was obtained prior to all study activities (Pro00105175). The PI obtained electronic written consent from participants and informed them that participation was voluntary, answers would be kept confidential, and they had the right to withdraw at any time.

3.3 Data Collection

We conducted semi-structured interviews with participants according to an interview guide that was created and piloted prior to implementation. The main aim of the interview guide was to understand the desired design requirements for a diabetes self-management mobile application among Black men living with diabetes. The first author, who was trained in qualitative research methods, conducted the interviews for the study. The first author's racial identity concordance and familiarity with cultural norms facilitated the recruitment of participants and development of trust during the data collection process (Randolph, 2018), thus promoting an open dialogue in which participants were likely to speak freely and feel able to share their experiences and be heard (Randolph, 2018). The research team for the study consisted of five investigators: three African American women (first, second, and fourth authors) one Latina woman (third author), and one Caucasian male (senior author).

Due to the COVID-19 pandemic, all data collection occurred online using secure video conferencing platforms and software or by phone. Each participant was interviewed once, for 25-95 minutes; all interviews were audio recorded and transcribed verbatim. Participants also completed a demographic questionnaire

which included items on age, gender, race, ethnicity, insurance coverage, and educational background.

3.4 Data Analysis

Data were analyzed using conventional content analysis—an inductive approach whereby codes are developed directly from the data (Hsieh & Shannon, 2005). There are three phases of conventional content analysis: preparation, organization, and reporting (Elo & Kyngas, 2008). During the preparation phase, personal identifiers from transcripts were removed and study ID numbers were assigned to each transcript. Transcripts were loaded into NVivo software (QSR International, 2012) to facilitate the analysis. The first author began with data exploration, including reading and re-reading through all transcripts to become familiar with the content and gain a general sense of emergent topics (Graneheim & Lundman, 2004; Miles et al., 1994). Throughout the data exploration process, memos were written to record impressions, thoughts, initial assessments, and analytic processes.

The organization phase began with selection of the meaning units; this process entailed highlighting exact phrases or sentences that appeared to capture key concepts or thoughts about patient-generated health data and diabetes management (Hsieh & Shannon, 2005). Codes were attached to meaning units,

known as codes, to describe the contents, then sorted into categories based on similarities (Hsieh & Shannon, 2005), after which the categories were grouped into higher order themes based upon similarities (Elo & Kyngas, 2008). Lastly, quotation exemplars for each code and category were identified from the data and compiled within a codebook.

The first author independently coded each interview, then reviewed the completed codes with corresponding data to the second author for coding confirmation. The second author reviewed the full codebook and independently coded 30% of the data. The first and second author met to discuss and reach consensus in coding and categorization; discrepancies were discussed until agreement was met. Data analysis was continued until saturation was reached (i.e., no new or relevant information was identified) (Morse, 2015).

Rigor

Scientific rigor of data collection and analyses were guided by the four principles of trustworthiness: confirmability, dependability, credibility, and transferability (Lincoln & Guba, 1985; Cope, 2014; Morse, 2015). Confirmability was ensured by maintaining an audit trail and providing rich and thorough descriptions of the study findings with quote exemplars to detail the desired app components (Elo & Kyngas, 2008). Dependability was maintained by using a

codebook and coding checks to ensure that the study processes were consistent across researchers and settings (Elo & Kyngas, 2008; Hsieh & Shannon, 2005). Disagreements in coding were resolved through discussion. Credibility was ensured by providing rich and detailed descriptions of the phenomenon combined with exemplar quotes (Elo & Kyngas, 2008; Hsieh & Shannon, 2005). Transferability of the research findings to other contexts was enhanced by rich descriptions in the data to facilitate comparisons (Elo & Kyngas, 2008; Hsieh & Shannon, 2005).

3.5 Results

The sample ($N = 20$) included participants living with diabetes. All identified as male and Black or African American and had a mean age of 44 years old. Participants' levels of education were: high school diploma or GED ($n = 22\%$), some college ($n = 20\%$), a bachelors' degree ($n = 36\%$), or graduate degree ($n = 22\%$). A total of 60% of the participants were diagnosed with type 1 diabetes, while 40% of participants were diagnosed with type 2 diabetes. (See Table 4.)

Table 4: Participant Demographics

Demographic Items	<i>M</i>	<i>Range</i>
Age	44	(25-70)
	<i>n</i>	%
Diabetes Type		
Type 1	12	60%
Type 2	8	40%
Education		
High School Diploma or GED	5	25%
Some College	4	20%
Bachelor's Degree	7	35%
Graduate Degree	4	20%
Income		
Prefer Not to Say	5	25%
Less than \$25,000	2	10%
\$25,000 - \$49,999	3	15%
\$50,000 - \$99,999	7	35%
\$100,000 - \$149,999	1	5%
\$150,000 - \$199,999	1	5%
More than \$200,000	1	5%

n = 20

Five major themes emerged from the data: (a) preferences for tracking patient-generated health data, (b) desire for tailored notifications, (c) tailored digital health recommendations, (d) need for increased support, and (e) user experience. Themes were divided into subthemes to provide a detailed overview of the topic being studied (see Figure 2)

Design requirements

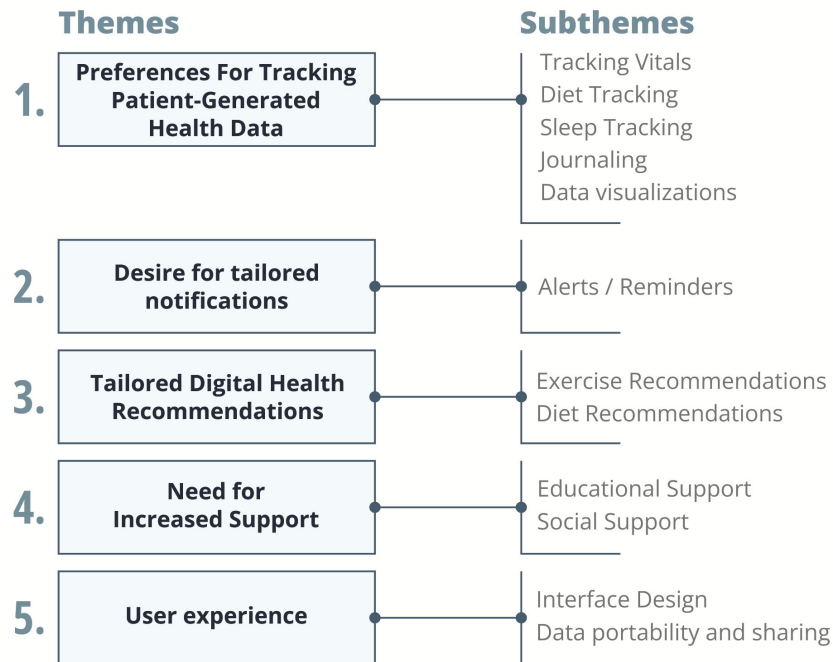


Figure 2: Illustration of Themes and Subthemes

Theme 1: Tracking Patient-Generated Health Data (PGHD)

This theme represents participants' perspectives on desiring the diabetes self-management mobile app to have a logging and tracking functionality. For instance, participants discussed how tracking patient-generated health data (PGHD) can aid diabetes management. The subthemes associated with this theme (discussed in detail below) include desired features within the app: (a) tracking vitals, (b) tracking diet, (c) tracking sleep, (d) journaling, and (e) data visualization.

Subtheme: Tracking Vital Signs. A majority of participants discussed their desire for a diabetes self-management app with the capacity to track and record vital signs (e.g., blood glucose level, blood pressure, weight). In addition, there was widespread discussion among participants about the need for an app with a continuous or automatic glucose monitor that could display blood glucose levels throughout the day on a chart. Several participants suggested providing a tool within the app to physically take their vitals: “If we could tell my blood pressure through the app . . . record my EKG and . . . track my stress, . . . that would be an app that I would like” (P3). Similarly, participants expressed a desire for a logbook that could update readings of all activities hourly, allowing them to detect trends and gain insights. For example, by monitoring blood glucose and blood pressure levels at various times of day, individuals could link changes in blood glucose to specific activities or investigate how specific activities, meals, or fasting affected their blood glucose levels. Lastly, several participants wanted an app that could produce an estimated hemoglobin A1c value based on their ongoing blood glucose tracking.

Subtheme: Diet Tracking. Participants highlighted a desire for the app to monitor calorie consumption and carbohydrate intake. They discussed incorporation of a carbohydrate counter to record the amount of carbohydrates

consumed; they requested features that could provide specific nutrition information for each food item and food substitutions and for blood glucose regulation. Participants expressed that they would value learning how their blood glucose levels change in response to food they eat (e.g., how quickly or gradually foods high in protein or sugar raise blood glucose levels) and that such a feature would enable the user to make informed meal choices and log their carbohydrate and calorie intake more precisely. One participant explained,

If there's a way to scan . . . before you eat something . . . [and] let you know this is how much sugar is in it, or this is what it can do to your blood sugar . . . I think that'd be helpful. (P3)

Another participant suggested that a list of meal items be included in the app along with a link which the user can tap to receive information about individual food items.

Subtheme: Sleep Tracking. A majority of participants advocated for the app to incorporate a sleep tracking component into the software. Participants felt that such a feature would be a beneficial tool for optimizing sleep patterns, given that a sufficient sleep routine greatly aids in maintaining normal blood glucose levels. The tracking tool would ideally allow the application to compare the

participant's sleep patterns to their blood glucose patterns. In one participant's words,

[S]leeping can be kind of tough when your glucose levels are fluctuating up and down... if I could see . . . the time I was asleep in and . . . correlation to . . . my blood sugar was high or something . . . that would be a cool feature, I think. (P12)

Subtheme: Journaling. Several participants stated their desire for a journaling feature to document information about their physical health and emotional state during day-to-day experiences. A few participants expressed that a journaling would be a helpful tool to use as an outlet to capture mood, given that males with diabetes are at higher risk for depression. One participant shared, “[M]ales have a lot more depression than a person living without diabetes, and I know that journaling is a great tool to help with depression.” (P12) One participant specified that it would be helpful to have an alarm that would remind the user to journal if they wanted to.

Several other participants mentioned that journaling could be helpful specifically for Black men due to stigma surrounding mental health.

Subtheme: Data Visualizations. Most participants expressed that charts are the most important elements of an app because they can enable end users to (a)

see broad and specific patterns or fluctuations at a glance; (b) understand, interpret, and possibly maintain glucose control; (c) view their blood glucose levels and other short- and long-term indicators (e.g., insulin basal rates, HbA1c) of how their diabetes is progressing; (d) indirectly learn steps to improve glucose levels by noting how specific activities affect their blood glucose levels or other indicators. This data could help participants make informed decisions about future dietary or behavior change or scheduling their activities. Participants discussed wanting charts that illustrated their daily patterns, low or high glucose events, and average glucose values over specific periods of time. One respondent noted,

The app should have a few different graphs. It would have the daily patterns, which helps out a lot, knowing where I'm at with my glucose levels. Time in target is probably my favorite, mainly because before I work out, I always want to make sure I'm in that range. It would have low glucose events and show you your average glucose throughout the day or, like, the 14 days that you have it, and then the biggest one is just a daily graph. One that pops up when you scan your glucose levels. (P12)

Theme 2: Desire for Tailored Notifications

This theme represents the types of notifications or messages that participants would like to receive from their application. Included in this theme are participants' specific discussions of the alarms and reminders they would like the app to have.

Subtheme: Alerts and Reminders. Participants described that the app should contain alert features which can aid in monitoring changes in their vitals. They discussed ways in which the app might notify users of emerging patterns and reported that alerts should inform users of abnormally high or low blood glucose levels.

While discussing these notification features, participants suggested that the app should include a function that would allow users to set reminders for specific issues that they may forget to do, such as: taking medication, monitoring blood glucose levels, engaging in physical activities, resting, eating, or goal setting. In reference to a reminder to address low blood glucose, one participant shared:

That'd be cool, 'cause I know it beeps at you, which is helpful. But it would be cool if it was like . . . a little robot . . . like [a] butler, kind of gives you like, "Hey you're low. Do something about it." (P 17)

Another participant who wanted the app to monitor the personal goals he has set for maintaining his diabetes and alert him when he achieves them stated:

Something that ... after I reach my goal, it says "good job" and "great job" ... that's encouragement, whether it's coming from a person or ... from the app itself, it is encouraging. (P19)

Most participants believed that tailored notifications would assist them in monitoring their levels and making informed treatment decisions.

Theme 3: Tailored Digital Health Recommendations

Participants stressed the importance of receiving personalized and tailored recommendations from the app. They indicated that the app would be highly helpful if it provided them with recommendations tailored to their preferences, previously collected health data, and behavioral patterns. The following subthemes broadly illustrate the types of tailored recommendations desired: (a) diet recommendations, and (b) exercise recommendations.

Subtheme: Diet Recommendations. Participants suggested a diabetes app that not only monitors and logs their blood glucose levels but helps them to organize meals and suggests diabetic-friendly foods. They stated that the app should include information about foods they should eat and those they should strictly avoid. Participants said an app that recommends foods tailored to the end user's

likes and preferences would help them control their blood glucose and reduce weight. In addition, the app might tell individual users how many grams of carbohydrates they should consume at each meal to maintain a stable blood glucose level. One participant explained,

"Let's say I was eating a bowl of salad . . . and the app tells me, "Hey, you know, if you use this bowl of salad to replace this meal...it can reduce your blood sugar by 0.7 points after six, seven months" . . . it gives you encouragement to, like, keep going. (P6)

Other participants wished that the app deliver insulin automatically based on the food it senses the participant is eating to cut down on user error when carb counting. Several participants wanted a feature that allowed them to scan food with their camera to estimate how the amount of sugar in it would impact their blood glucose level based on previous trends.

Subtheme: Exercise Recommendations. Participants desired an app that would suggest different workout routines to help in adopting a healthier lifestyle. Participants also shared that it would be extremely useful if the app could propose or advise activities based on glucose levels. Participants indicated that the app should send notifications and suggest physical exercise if it detects a spike in their blood glucose level. One participant suggested a warning indicator

such as a message that reads, “*Your blood sugar is 212. Go take a walk outside...I see your blood sugar is dropping. Do a few push-ups.*” (P5) Participants proposed getting personalized recommendations for workouts, including the type of activity they should undertake, based on their logs.

Theme 4: Need for Increased Support

Participants discussed the support features they would want to see within the application. They discussed the need for two types of support: diabetes-related knowledge and information, and a social forum that allows individuals with the same condition to connect and support one another. These recommendations comprise two subthemes: (a) educational support, and (b) social support.

Subtheme: Educational Support. Most participants expressed interest in a feature that contains educational information regarding preventative measures and treatment of diabetes. They felt the app should include articles, blogs, podcasts, or any other useful information on the maintenance and management of diabetes. Participants said they want an app that can serve as a central source of educational information about diabetes for patients. As one participant explained,

You know, articles and things that would be relevant to diabetes . . . that I might want to know about. Say, if I want to . . . hear about technology . . . about different medications, different podcasts about diabetes that they refer me to that are to my liking . . . or you know, equipment, things of that nature, information about navigating insurance, all that kind of stuff. If there was to be an app that had all that in, making that like a one-source resource place to get all that information, that could be kind of cool. (P9)

The participants mentioned that information on various forms of diabetes and its general symptoms should be provided in the app. They mentioned that they would want information about what causes diabetes and what factors make people more likely to develop it. Participants further mentioned that the app should contain information about the negative effects of uncontrolled diabetes and preventative treatments or actions to keep blood glucose levels stable. They said that access to such educational materials or resources would help Black men with diabetes better understand their condition and available treatment options, including holistic or non-Western modalities. One participant shared,

I think it would be interesting to have a specific section that . . . caters towards Eastern medicine and . . . the holistic aspect of how to cope with

your diabetes, or . . . utilizing non-traditional ways to help with your diabetes, I guess, is what I'm getting at. (P14)

Subtheme: Social Support. The participants suggested that the app include a social support component, such as a community forum or support group, which would allow them to communicate with other diabetes patients who share similar issues. One participant specified that they would like the app to have *“support groups, you know. People. They can talk to you . . . and they message you back with answers to your questions.”* (P8) They recommended introducing a tool that would allow users to post questions, share diabetes-related news, and exchange information and experiences with the online diabetes community. Such forums would allow them to interact with new people while also providing opportunities to create informative support among individuals with diabetes. Participants stated that such forums can provide people with information on various local activities taking place around them:

I would say a place where people can post about meetup groups, you know, . . . I'm assuming you know if the device has the ability to see your location, . . . point out when there's a meetup group or maybe even having an ability to connect with other people, build a community from that. (P12)

Several participants asked whether the app might involve family members and perhaps educate them regarding diabetes and how to offer support to the end user.

Theme 5: User Experience

Participants discussed the app's user experience. Participants detailed their desired overall experience of using a diabetes self-management application and how feasible use should be. Based on their views, this theme is divided into two subthemes: (a) interface design, and (b) data sharing.

Subtheme: Interface Design.

A majority of participants expressed that the data within the app needs to be centralized, meaning that all needed components can be found within just one app: *"Not one app, two apps, three apps, but everything is in one place. I'd prefer to keep my data in one place."* (P2) The participants shared that the app should be simple and easy to use. They also stated that the app's interface should be visually appealing, and information in the app should be easily accessible and presented in a simple manner. Several participants recommended designing an app with Black people in mind:

I just would hope that an app would make information more . . . readily available, and you know, maybe it wouldn't be as challenging to find . . . it

can be a bit challenging . . . Specifically, [for] men of color, [for a] Black man . . . it's not always out there, and it's not always easy to find. It would be cool if an app had articles about different technologies, podcasts, information on how to navigate insurance, all that kind of stuff. If there was to be an app that had all that in, making that like a one-source resource place to get all that information, that could be kind of cool.

(P20)

Many of these applications, participants noted, are set up in this generic way. Participants expressed that they would like the application to be customized to their needs and preferences. Another participant shared that the interface should be designed and personalized with the Black man in mind:

It has to be hard core, you know. . . let the person understand what's at stake. You know, it can't be no Mickey Mouse Disney app . . . Don't sugarcoat it . . . like man, if it's gonna be for Black men, we don't like it even sugarcoated. Give it to us how [it] needs to be told to us, so we can get on. If we decide not to . . . that's on us, but we know what's at stake.

(P8)

One participant suggested that the app should deliver a personalized experience to each user and adjust to their preferences based on their logs and

patterns; for instance, the app's recommendations would account for the user's past blood glucose levels, physical activities, food patterns, etc.

Subtheme: Data Sharing. A majority of participants identified data portability or sharing as a significant factor within the app. Many participants stated that since the app would allow them to record their blood glucose readings and other important data, they would like a feature that would also allow them to email comprehensive data reports to their providers prior to a clinic visit:

I think that the overall perspective is, one: that the app would give a comprehensive view of the management side of diabetes, because that's the part that the patient is doing. But would also be able to package that data and send it over to the doctor for the periodic visits. So, the app should be able to just create its own report that you can send to the doctor, two days before the visit, three days before the visit, and get some feedback after the visit. (P2)

Participants expressed that an app with a feature that could generate its own report prior to the patient's health care appointments would allow the patient to obtain early feedback from their health care provider. Participants discussed needing an app that would work universally with providers'

equipment, alleviating the need to change equipment if their provider switched between various brands. Participants discussed wanting to be able to control insulin pumps through the phone app. Additionally, it was important that the app worked across both Apple (iOS) and Android platforms and had the capability to connect to all brands of smartwatches.

3.6 Discussion

The purpose of this study was to investigate desired design requirements for a diabetes self-management app among Black men living with diabetes. This study's qualitative findings highlight key components of a diabetic self-management application suggested by Black men with diabetes. Five major themes emerged from the data: (a) preferences for tracking patient-generated health data, (b) desire for tailored notifications, (c) tailored digital health recommendations, (d) need for increased support, and (e) user experience. Black males sought a centralized health application which was designed and personalized exclusively for them. In addition, participants largely wanted an app that could suggest activities or solutions based on their glucose levels and provide educational information on diabetes self-management that was specifically tailored to Black men.

Participants stated that applications for diabetes self-management should provide increased levels of support, including educational support and social support. They expressed that an increase in tailored digital health recommendations could be achieved in a variety of ways, including through app suggestions on healthier food options based on dietary preferences, and personalized physical activity suggestions based on real-time glucose values, dietary intake, overall personal goals set by the user, and available treatment options including holistic modalities. Self-management of diabetes necessitates the development of a social support system (ADA, 2019), which could be facilitated via message boards and chat functions. Participants recommended the development of a social support system via message boards and chat functions within the app. Similar to previous research, participants indicated the need for mental health support, which suggests there is a gap in addressing the psychological and emotional aspects of diabetes self-management (Bonet Olivencia et al., 2021). Addressing such needs enhances an individual's ability to cope with stress associated with diabetes self-management (Yoon et al., 2022). Indeed, our findings show that social support is a motivational feature desired by participants.

Some findings are consistent with previous research regarding desired features for a diabetes self-management application. For example, according to evidence-based guidelines published by the American Diabetes Association (2020), tracking one's blood glucose levels is one of the most essential diabetes self-management tasks. Other crucial self-management tasks include physical activity, adequate dietary control, proper medication dosage, and education (Bonet Olivencia et al., 2021). Similarly, the findings of the present study indicate that Black men with diabetes prefer application functions that allow them to log glucose values, visualize their status, and receive helpful tips and feedback on diet and exercise as well as reminders for essential self-care activities. In addition, the participants indicated the need for dietary options within the application to maintain glycemic control, and the usefulness of a carbohydrate tracker.

Patients were particularly interested in gaining access to educational resources, including preventative strategies, to help them improve self-management. Resources that piqued participants' interests include articles, blogs, and podcasts that serve as a centralized source of information. These results support the importance of aligning educational content for a mobile application to the user's cultural background and literacy (Bonet Olivencia et al., 2021).

It is cumbersome for people to use multiple apps to manage their diabetes, so it is important to provide as much support as possible in one place for ease of use. Participants in the present study indicated a desire to have one app to serve as a one-stop-shop. Many of the desired features discussed within this present study (e.g., medical care referrals, glucose tracking, data management, lifestyle support, medication management) already exist within several separate apps but not necessarily within one comprehensive app. The findings of this present study are congruent with recommendations for a more centralized application that addresses more than one or two essential facets of diabetes self-care (Yoon et al., 2022). A singular app that comprises multiple features would allow comprehensive patient-generated health data to be aggregated easily, thus facilitating the clinicians' ability to interpret data thoroughly and comprehensively.

A novel contribution to the literature is that participants desired an app that could provide predictive analytics. Most participants interviewed wanted predictive analytics, such as a forecast of glucose values resulting from the inclusion or exclusion of certain foods, which is a new finding for this area of research. Participants believed that with the help of predictive analytics, they would be able to make more informed decision about their diets and

management decisions. The desire for predictive analytics among participants in this study highlights the need for diabetes management tools that are tailored to the preferences and behavioral needs of end users. Incorporating predictive analytics into digital health tools for diabetes management can result in more user-friendly and personalized solutions that are more likely to be adopted and utilized by individuals with diabetes (Donnelly, 2020).

There are several implications for clinical practice. For example, clinicians should consider the cultural appropriateness of digital health tools recommended to Black men with diabetes. This involves making sure that the tools are practical, easily accessible, and customized to their specific requirements and preferences. Future research should concentrate on assessing the efficacy of digital health tools in managing diabetes in Black men. This could include performing randomized controlled trials to compare the effectiveness of various digital health tools and interventions in enhancing diabetes outcomes amongst Black men with diabetes.

This study has multiple strengths including focus on an understudied population, recruitment of participants across the U.S, and diverse income of participants. However, authors did not assess digital health literacy, years since diagnosis, or occupation which could have informed findings. Nonetheless, the

findings emphasize the significance of end-user input for developing diabetes self-management application interventions for Black males living with diabetes.

3.7 Conclusion

Findings from this study suggest the need for a diabetes management smartphone application which can be tailored to Black men's preferences. The data showed that Black men wanted an app which included the ability to track multiple streams of patient generated health data, customize notifications, receive tailored recommendations, offered educational support and social support. Additionally, it is recommended that the app be visually appealing with information presented in an accessible and easy to understand manner. These findings delineate multiple areas where digital health applications can be designed or adapted to address the needs self-management needs of Black men with diabetes in ways that are currently not being addressed. Digital health applications, tailored specifically for Black men, may provide a suite of easily accessible, centralized, and customizable tools to aid Black men with their diabetes to improve self-management as well as assist their clinicians with diabetes care delivery. The present study also highlights the culturally relevant educational, dietary, and predictive analytic feature needs in this under-researched population Findings from this study may guide the development or

adaptation of future diabetes management apps or contribute to future research aimed at designing specific interfaces for such applications for this population. Future research should investigate ways to address the needs of Black men using digital health to manage their diabetes. Additionally, research should focus on improving the clinical effectiveness of digital health tools for diabetes management amongst Black men.

4 Clinicians' Perceptions of using Patient-Generated Health Data to Guide Clinical Decision-Making and Management of Diabetes: A Qualitative Study

4.1 Introduction

Around 10 percent of the population in the United States, equivalent to 37.3 million Americans, is affected by diabetes, a chronic health issue with significant implications (CDC, 2022). Diabetes is currently the seventh leading cause of mortality, and its prevalence has increased by 60 percent, resulting in medical costs and lost income totaling around \$327 billion (Adu et al., 2019; CDC, 2022). Achieving optimal outcomes in diabetes requires stringent management and monitoring of blood glucose levels, weight, medication adherence, and lifestyle behaviors such as diet and exercise (Boyle et al., 2015).

Advances in digital health offer novel approaches with great potential to improve diabetes management, including the ability to collect and utilize patient-generated health data (PGHD) in real time (Shaw et al., 2019). The US Department of Health & Human Services defines PGHD as health-related data “created, recorded, or gathered by or from patients” to address a health condition. Individuals can use wearable devices, mobile health apps, and other technologies to track, monitor, and report their PGHD, thus enabling them to record information about their health and wellness, keep track of their activity

levels, enhance their self-awareness of health, and utilize tools to manage their health conditions. Shapiro et al. (2012) emphasize that such approaches permit patients rather than health care providers to take responsibility for documenting and distributing their data. PGHD can supplement data from clinical visits to offer a more complete picture of the patient's daily behaviors, surroundings, and lifestyle (Demiris et al., 2019). Additionally, PGHD collected outside clinic visits and submitted to providers could allow remotely monitored health care delivery (Lavallee et al., 2020) as well as effective care tailored specifically to the patient's individual health condition and circumstances (Cohen et al., 2016).

Digital health technologies can facilitate diabetes management by enabling the tracking, recording, and monitoring of multiple data streams of PGHD such as blood glucose, medication and insulin administration times and doses, nutritional intake, and physical activity (Giordanengo et al., 2019; Hartz, Yingling, & Powell-Wiley, 2016; Sieverdes, Treiber, Jenkins, & Hermayer, 2013). Moreover, these data can be transmitted in real time between patients, clinicians, and health systems to provide a better picture of the patient's health between clinic visits (Shaw et al., 2019). PGHD can improve communication and engagement between patients, health care teams, and providers while providing more comprehensive longitudinal data about the individual's health (Cohen et

al., 2016). Digital health technologies provide clinicians and their patients with a unique opportunity to engage with PGHD to guide the management of diabetes.

Given the ongoing advances in health technologies, health care providers must remain knowledgeable of the digital health technologies currently available to gather clinical patient data (i.e. electronic health records, patient portals, wearables, patient sensors) (Demiris et al., 2019; Nittas, Lun, Ehrlert, Puhon, & Mutsch, 2019). Because there are multiple types of digital health technologies, and all require time and training to use during patient visits, clinicians may be concerned that their use could hamper workflow efficiency, increase provider liability and accountability, and change patient expectations of how clinic visits should operate (Lavalley et al., 2020). Researchers and nurse informaticists must address technical challenges by confirming the accuracy and validity of PGHD transmitted from patient devices (Lavalley et al., 2020), managing data security risks (Shaw & Ferranti, 2011), and standardizing the data collected (Chung, Cook, Bales, Zia, & Munson, 2015). It is necessary to be mindful of (a) the data the health care system is amassing, (b) what health care practitioners might be clinically required to do with this PGHD, and (c) the changing roles of health care practitioners/clinicians and the health care system.

The conventional health care landscape is transforming in response to innovative technologies and digital health initiatives incorporating PGHD that offer targeted solutions. Although digital health and PGHD hold promise for enhancing diabetes management and support, few studies have examined providers' perspectives on the use of PGHD. The purpose of this study, therefore, was to explore clinicians' perspectives on barriers and facilitators to the use of PGHD to guide the clinical decision-making and management of patients with diabetes. Findings will provide new insights into providers' perceptions of the use PGHD within their clinical care and inform their patient education regarding how to use PGHD to improve diabetes self-management.

4.2 Methods

Study Design, Sample, and Setting

This study adopted a qualitative descriptive design. This type of research design facilitates a clear, in-depth understanding of the study phenomenon by examining it from the participant's perspective through their direct descriptions of experiences or perceptions (Creswell & Plano-Clark, 2017; Sandelowski, 2010). A qualitative descriptive design was considered the most appropriate approach for this study as its objective was to develop an in-depth understanding of clinicians' subjective perspectives on barriers and facilitators to the use of

patient-generated health data to guide the clinical decision-making and management of patients with diabetes.

All participants were invited to participate by email or in person. Clinicians were eligible if they (a) had provided care to adults with diabetes mellitus for at least 1 year, and (b) were employed by the participating health system. There were no exclusions. We purposively sampled participants to include a diverse range of providers with and without prescribing privileges, including doctors, nurse practitioners, nurses, and diabetes educators.

Ethical Considerations

The PI obtained approval from the Institutional Review Board before commencing research activities (Pro00071569). The study participants were informed that their participation in the research was voluntary, information obtained from them would be kept confidential, and they could withdraw at any stage in the research process. Their electronic written consent was obtained.

4.3 Data Collection

In this study, semi-structured interviews were conducted with consenting participants ($N = 21$) from May 2019 – March 2020 from one academic medical center located within the Southeastern United States. The data collection process consisted of three major steps. In the first step, a semi-structured interview guide

was designed and piloted to identify and refine any problems with the wording of questions, estimate the resources required, and determine whether the preliminary data matched the research intention of developing an in-depth understanding of desired design requirements for a diabetes self-management app among Black men living with diabetes.

The research team collectively developed a semi-structured interview guide with open-ended questions. Interviews began with general questions about the providers' thoughts on the use of digital health technologies for managing diabetes. The initial questions for the interview included the following:

1. "What barriers do you see to using real-time data in your clinical decision making?"
2. "What would enable you to use patient-generated health data (PGHD) in your clinical decision making?"

The second step involved the recruitment of participants, and as a third step, the PI (AD) conducted the semi-structured interviews. Data were collected either through a private in-person conference or phone conversation, or over a video conferencing platform. The semi-structured interviews were conducted one time, lasted between 25-30 minutes, and were audio recorded and

transcribed verbatim. Interviews were conducted by the first author. Participants were also asked to complete a demographic questionnaire which included items on gender, race, clinical role, and years of practice. Participants received \$50 for their participation.

4.4 Data Analysis

The audio records were transcribed, and the first and second authors verified the transcripts against the audio. The data were then analyzed using the conventional content analysis method. Hsieh and Shannon (2005) described this method as an inductive approach in which codes are developed directly from the data. The conventional content analysis approach consists of three phases: data preparation, organization, and reporting (Elo & Kyngas, 2008). The preparation phase involved the removal of personally identifiable information. During this phase, all information that could be used to identify participants such as names and places of work were removed, and unique identifiers were assigned to each transcript. The transcripts were then imported into NVivo software for analysis. The first author began exploring the data by reading and re-reading through all transcripts to familiarize themselves with the data and captured their initial impressions in memos.

The organization phase entailed selecting units of meaning, phrases, or sentences that captured concepts related to the research question; attaching codes to the units of meaning; sorting the codes into categories based on similarity (Hsieh & Shannon, 2005); and, finally, grouping the categories into overarching themes (Elo & Kyngas, 2008).

The first author independently coded each interview and submitted the completed code and corresponding data to the second author for coding review. The second author reviewed the entire codebook and independently encoded 30% of the data. The two authors scheduled frequent meetings to review the codes and categories, and to discuss any discrepancies. The coding process continued until saturation was reached (i.e., no new codes were identified).

As recommended by qualitative researchers, the authors maintained an audit trail of all analytical actions (Morse, 2015; Whitemore, Chase, & Mandle, 2001). Detailed findings are reported in the following section.

Rigor

Scientific rigor in qualitative research is based on the four principles of trustworthiness: confirmability, dependability, credibility, and transferability (Lincoln & Guba, 1985; Cope, 2014; Morse, 2015). Please refer to table 5.

Table 5: Strategies used to Establish Scientific Rigor

Principles	Strategies Used
Credibility	Providing rich and detailed descriptions of the study phenomenon supported with verbatim quotes
Transferability	Providing rich descriptions of the phenomenon under study
Dependability	Developing a codebook Engaging an expert to review the procedures
Confirmability	Keeping an audit trail Developing rich descriptions of the study findings with quote exemplars

Credibility assesses whether the research findings are a true representation of the participant's perceptions and experiences (Elo & Kyngas, 2008; Hsieh & Shannon, 2005); it was established by providing rich and detailed descriptions of the study phenomenon supported with verbatim quotes.

Transferability describes a measure of the degree to which research findings can be generalized to similar contexts (Elo & Kyngas, 2008; Hsieh & Shannon, 2005); it was enhanced by providing rich descriptions of the phenomenon under study.

Dependability ensures consistency across researchers and settings (Elo & Kyngas, 2008; Hsieh & Shannon, 2005); it was maintained by using a codebook and engaging a qualitative expert to review the codes. Confirmability maintains objectivity in qualitative research (Elo & Kyngas, 2008); it was ensured by keeping an audit trail and developing rich and thorough descriptions of the

study findings with quote exemplars. During the analysis process, the authors verified the accuracy of the transcripts against the audio recordings prior to coding and analysis, met routinely to discuss coding developments, had a qualitative expert (second author) audit the codebook to provide feedback on codes matching the exemplar quotations, and maintained an audit trail of our actions and memos (Morse, 2015; Whittemore, Chase, & Mandle, 2001).

4.5 Results

Participants (N = 21) were 76% White with an average of 12 years of practice. 23% of participants were Female. The sample included physicians, nurse practitioners, nurses and a diabetes educator. Please see table 6 for more details.

Table 6: Participant Demographics

Demographic Items	N (Percentage)
Gender	
Male	5 (23.8%)
Female	16 (76.2%)
Race	
White	16 (76.2%)
Black	2 (9.5%)
Asian	1 (4.8%)
Other	2 (9.5%)
Specialty	
MD	14 (66.7%)
NP	2 (9.5%)
RN	4 (19%)
Diabetes Educator	1 (4.8%)
Years in Practice	Average (Range)
	12 (1-40)

N = 21

Three themes emerged regarding clinicians' perspectives of the utility of patient generated health data to guide clinical decision making and self-management of diabetes. These themes include a) utilizing PGHD to guide care, b) concerns and limitations of PGHD use, and c) strategies for optimizing PGHD use. Themes were divided into subthemes to provide further detail of the topic explored.

Utilizing PGHD to Guide Care

The theme "utilizing PGHD to guide care" details clinicians' perspectives on the utility of incorporating patient-generated health data within clinical care. The subthemes include a) ability to provide tailored treatment recommendations and b) improved patient engagement.

Subtheme: Ability to provide tailored treatment recommendations

Clinicians discussed using PGHD to guide clinical decision making and patient care. Clinicians stated that it was good to have a patient's PGHD because there are a lot of data points between visits and it helps tell a story that is a part of the bigger picture of the patient's health. Since many clinicians only see patients every couple of months, and a lot happens during those months, data outside of clinic values can illustrate if the patient's diabetes management is improving. Many patients can overestimate or underestimate certain things, such as activity

levels, so it is helpful to have objective data to work with. PGHD and CGM data can also give the clinician an idea of what is contributing to patient's outliers or give insight on if medications are working or adjustments are needed. PGHD allows for monitoring patients' consistency or see if they are struggling with something specific. Clinicians gave examples of how they employed the patient generated health data within the patient assessment. Clinicians shared that, *"If you have actual data, it helps present the case of where we need to kind of focus changes."*

(Participant 01)

Clinicians explained how reviewing reports that show estimated A1c and blood glucose levels before and after meals, along with accompanying symptoms, helped identify trends in blood sugar fluctuations. The clinician found it helpful to compare daily reports side by side and walk through them with the patient to identify habits and day-to-day trends. They also noted that analyzing data can help identify trends in low blood sugars, particularly after a hard workout or high activity levels, allowing for interventions such as a temporary basal rate adjustment in insulin pumps. Clinicians believed that data analysis could provide valuable feedback to patients in monitoring their progress and identifying trends over time. They acknowledged that patients are typically

only seen every few months, and data could help patients stay on track and make adjustments to their diabetes management plan.

“Patient-generated health data can help patients stay on track and make adjustments to their diabetes management plan.” (Participant 10)

Clinicians suggested that monitoring personal hypoglycemia or hyperglycemia sensations could be helpful, which could be corroborated with a Fitbit or an Apple watch, as everyone experiences these symptoms differently. They explained that hypoglycemia symptoms could include various things from clammy and sweating to dizzy or ravenous. The clinicians agreed that monitoring different data points is crucial to make wise decisions and modifications to the patient’s treatment plan.

“I think their personal hypoglycemia or hyperglycemia symptoms are helpful and that could be corroborated with a Fitbit or an Apple watch that checks heart rates since there is usually some tachycardia with hyper, hypoglycemia cause everyone experiences that a little differently.” (Participant 14)

Another benefit of using PGHD that was identified by the clinicians was personalized treatment recommendations. PGHD allowed healthcare providers to gather comprehensive and individualized information about their patients’ health status, which in turn enabled them to tailor treatment plans to meet each

patient's specific needs. Clinicians agreed that even though using PGHD for personalized treatment recommendations could be time-consuming, it was ultimately beneficial.

For example, clinicians highlighted that setting broad goals without considering patients' capabilities and lifestyle was not beneficial. Instead, knowing their activity level, preferred activities, and time of day when they are active could help tailor a plan that feels achievable. They further explained that for a patient who is only averaging 2000 steps and telling them to walk 10,000 steps is not achievable. Additionally, knowing the time of day when patients are active is also important. Clinicians further expressed their hope for patients who adhere to the personalized plan, stating that just setting broad goals would not mean much. By looking at patients' PGHD, healthcare providers can see what they are doing and tailor a plan to their specific needs. By examining trends, such as steps taken at the beginning and end of the year, healthcare providers can identify areas for improvement and suggest ways to incorporate activities. *"You can really tailor it more to that person, I think." (Participant 07)*

Clinicians noted the benefits of PGHD in identifying patterns that patients may not be aware of, leading to better treatment. They gave an example of how

reviewing a patient's log using PGHD could reveal that their hypoglycemia threshold was lower than they realized, which could lead to feelings of tiredness.

"I think that would be interesting because then you know, someone comes in and says, you know, I haven't had any lows, but this last month I've been feeling really tired and then you can look at their you know, their log and you can say oh well, no, you have actually had lows." (Participant 14)

Clinicians suggested that using tools such as Fitbit could be helpful in gaining a better understanding of a patient's overall health and activity levels. They highlighted that providing patients with concrete goals, such as walking a certain number of steps, can increase patient motivation.

"Using patient generated data, you can make more tangible goals with the patient. Like you can say, yes I know you usually walk x amount of steps a day. Lets get to this certain number of steps a day. I think that would be really helpful." (Participant 9)

Clinicians expressed concerns over exacerbating health disparities with the use of PGHD. More specifically, that certain patients would get more granular information and more tailored treatment plans possibly facilitating better health outcomes than patients who don't collect or gather PGHD.

Subtheme: Improved patient engagement

Clinicians highlighted the importance of improved patient engagement via patient accountability and motivation through tracking of their health information. However, they also acknowledged the need for feasibility and careful handling of patient data.

“If they know that their information is being sent and being tracked, I think that really does something for patients’ engagement and motivation.” (Participant 04)

Clinicians underlined the importance of data analysis and feedback for encouraging and enlisting the participation of patients in their own healthcare. They believed that empowering patients through PGHD could lead to better treatment outcomes.

“Maybe we empower more patients with their data. CGMs and sensors allow us to do that.” (Participant 15)

Concerns and limitations of PGHD Use

This theme details the concerns shared by clinicians in regard to data clinical use of PGHD. The subthemes include a) time and billing and b) data validity.

Subtheme: Time and Billing

There was a consensus between clinicians that having access to more patient data is “good”, however time may be a barrier to incorporating PGHD into clinical care. The current workflow includes nurses manually scanning patient PGHD reports into EHR, which can be time-consuming due to long reports. Clinicians reported a workflow of reviewing pump settings, making sense of the data and patterns presented, showing, and explaining the data to the patient. Then the clinician must also assess the patient, come up with a treatment plan or create a possible change plan of care, prescribe, and write a note, which is time consuming.

Furthermore, reviewing PGHD with the patient is time consuming since many patients do not understand the reports for themselves and require patient education around interpreting their reports. Clinicians highlighted that billing for reviewing PGHD is a concern as most clinicians are not being compensated for reviewing data and would have to review PGHD in their own personal time. The ability to bill for using PGHD could incentivize providers to incorporate the use of these devices in patient care and improve patient engagement and accountability.

“I mean, I think, with where health care is going, if this is something that could be like, billable or someone could I guess, just sit in their office for half a day and mine all this data and have either a virtual visit.” (Participant 10)

Clinicians stated that primary care providers may not have enough time to review PGHD data outside of scheduled office visits due to their busy schedules and that it could be difficult for primary care providers to manage this data and incorporate it into their patient care. Primary care providers have to balance multiple responsibilities, such as patient consultations, administrative tasks, and other healthcare duties, which can limit their ability to review PGHD data frequently. Clinicians stated the need for healthcare organizations to develop strategies to support primary care providers in managing PGHD effectively, such as providing training and education on how to interpret and use PGHD data, or allocating resources to support the review and analysis of this data.

“If you’re in a practice where it really is the primary care provider doing all of this then it’s gonna be really challenging to look at this outside of office visit time.” (Participant 07)

Clinicians raised concerns about the feasibility of reviewing PGHD, given the amount of data that could be generated and the limited time that healthcare providers have to review it. They expressed the opinion that it might be more feasible to review PGHD if it were a billable activity, allowing them to devote more time to the task. Clinicians’ comments highlight the need to find ways to

incentivize healthcare providers to review PGHD data. Without a clear benefit or compensation, healthcare providers may be unwilling or unable to devote sufficient time and resources to this task. By establishing a billing code or other form of compensation for reviewing PGHD data, healthcare organizations can help to ensure that patients receive the benefit of this valuable data, while also supporting the work of healthcare providers.

"I'm not sure like you know, that we have the time to do that, unless somebody could set up some sort of, you know, if it was billable and I could have an afternoon to sit and virtually review data and give accommodations, I'd be happy to sit in my office and do that if I could bill for it but if it was to be done on my own time." (Participant 10)

Subtheme Theme: Data Validity

While it was agreed that both PGHD and clinician collected data needs to be validated before used, clinicians shared concerns specific concerns about the use and validity of patient generated or patient collected health data. Nurses questioned how they could verify if the patient has been using, maintaining, or calibrating their personal device appropriately to avoid false readings. Thus, nurses shared they wouldn't feel comfortable dosing a patient's medication according to the patient's personal device or PGHD. Furthermore, it was discussed

that device readings can be inconsistent, and the sensitivity of the tools used to collect PGHD was questioned. there is no current workflow to assess the validity of PGHD.

The potential for missing data was also discussed. The reliability of PGHD collected was also highlighted in regard to the potential for missing data. For example, the patient may exercise and forget to bring their phone on their person or a lot of patients might not carry their phones on their person continuously so the activity trackers are ineffective and data may be incomplete. Clinicians could not ascertain the validity of the data because CGM devices had low sensitivity to the patient and could collect activity data from anyone who was carrying the device. *“Validity could be an issue because it would give us false readings of four or five thousand steps when the patients were at home, for example, if someone else was using the device.”* (Participant 13)

Furthermore, certain patient exercises, like swimming, cannot be tracked with a phone. However, other clinicians shared that they believed that PGHD is reliable data and that PGHD logs may give more accurate data than if the patient just wrote it down themselves since patients can inaccurately document their data on paper forms. To build the provider’s sense of confidence in using PGHD, the clinicians expressed the need for data validation strategies.

Strategies for optimizing PGHD Use

This theme details strategies for optimizing use of patient-generated health data within clinical practice. The subthemes include a) patient education and b) integrated workflow.

Subtheme: Patient Education

Clinicians believed that patient education was vital for the proper use of PGHD to guide a patients' care and self-management. Clinicians identified that using PGHD could improve patient access to information about their diabetes management. With PGHD, patients could have access to real-time data on their glucose levels and other health metrics, which could help them make more informed decisions about their treatment. In addition, PGHD could allow patients to share their data with their healthcare providers, enabling them to work together to develop personalized treatment plans. Clinicians voiced concerns over the lack of patient access to information, highlighting the need for healthcare providers to prompt patients to download their own reports. *"Maybe it needs to start at that educational level, saying 'here's the way you download it, and I encourage you to do so.'" (Participant 02)* Clinicians emphasized the importance of reminding patients to upload their PGHD on time. They suggested using text messages, emails, or calls to remind patients to do so. They also proposed

creating accounts for patients in clinic to make it easier for them to access and upload their data.

Clinicians believed in educating the patient about the device and how it fit into their routine was crucial. Clinicians also *discussed the opportunity to educate patients on their data.*

“You should go over the patient-generated health data, make sense out of it and then show it to the patient and explain the data to them and then come up with a treatment plan.” (Participant 03)

Clinicians further stated that the choice of tracking method should be tailored to the individual patient, taking into account factors such as their level of education, socioeconomic status, and the duration of their diabetes. *“I think it depends on the patient, maybe like education level, maybe socioeconomic factors, how long they’ve had diabetes” (Participant 02)*

Subtheme: Integrated workflow

Clinicians identified the importance of having an integrated workflow with designated computers and staff to optimize PGHD use in clinical practice. They noted that having dedicated staff and computers for accessing and interpreting PGHD can help ensure that healthcare professionals have timely access to patient data and can make necessary interventions to improve patient

outcomes. Clinicians expressed that having designated computers and staff for PGHD use would be beneficial for clinics. They noted that not all clinics have the capability to assign a nurse to regularly review PGHD and follow up with patients.

“I think that some providers who have to actually think about or you can do without information regularly, right? You know, if you have the type of clinic where you had a nurse who was assigned to be looking at this and making calls, and following up with patients, that could be really neat.” (Participant 04)

Clinicians suggested that clinics could implement a rule of practice where they have additional staff members assigned to download and review PGHD during certain days of the week. They acknowledged that not all clinics may have the resources for this, but academic practices may have more help available.

“Maybe a rule of practice, for a clinic is that during certain days of the week, they have a few additional staff members, or may be only one person, you know, downloading PGHD, looking at outliers, goals, etcetera.” (Participant 04)

4.6 Discussion

The purpose of this study was to examine clinicians’ perspectives on barriers and facilitators to the use of PGHD to guide the clinical decision-making and management of patients with diabetes. The findings revealed that PGHD has

significant potential to improve patient care, promote patient engagement, and facilitate tailored treatment plans. However, there are also concerns regarding the validity of PGHD, which need to be addressed. The study also highlighted the importance of technology in facilitating PGHD integration into clinical workflows and suggested strategies for optimizing PGHD use.

While using patient-generated data in clinical decision-making and patient care was generally seen as beneficial, there was apprehension about how it could potentially exacerbate health disparities among patients who cannot or do not use such data (Veinot, 2018). Consistent with the literature, our findings demonstrate that providers are concerned that clinical use of digital health and PGHD could potentially contribute to health-care disparities as some patients may be unable to track their health data due to their disease, lack of engagement, limited access to technology, or insufficient medical coverage for reimbursement (Chung et al., 2015; Nundy et al., 2014).

The barriers related to PGHD use identified by providers in our study align with those found in other research, including work by Austin et al., which identified barriers pertaining to PGHD integration into the electronic medical record and concerns about insufficient compensation for time that health care providers would spend evaluating PGHD outside of scheduled appointments.

Similarly, respondents had unanswered questions about the types and frequency of data that would be most useful for monitoring health and making clinical decisions (Chung et al., 2015). This study aligns with previous research suggesting that providers are concerned about the reliability and validity of PGHD (Nundy et al., 2014).

Strengths

Our findings contribute to the literature by providing contemporary qualitative perspectives of clinicians regarding barriers to and facilitators of PGHD use to guide their clinical decision-making and management of patients with diabetes. Findings from this study will contribute to the underdeveloped knowledge base on how providers can work with patients to use PGHD to improve Diabetes self-management. Further, these findings provide new insights into clinical workflows currently in place and potential changes to clinical guidelines for PGHD use for diabetes management.

Limitations or Comparison to Prior Work

First, our sample included clinicians (in various roles) from the same academic health system in the Southeastern United States, which may have resulted in bias. Second, some interviews were conducted in person and others over the phone which could have influenced findings and clinicians willingness

to share. Lastly, our findings may not be generalizable or transferable to all clinicians working with PGHD from patients with diabetes; however, they represent the perspectives of a diverse group of clinicians on barriers and facilitators affecting the use of PGHD to guide clinical decision-making and management of patients with diabetes.

Future Research

Further research is needed to explore the testing and implementation of self-management digital health technologies and data visualizations tailored to be both patient-facing and clinician-facing. Specifically, research is recommended that aims to identify strategies to (a) help patients adapt to using various types of self-generated diabetes-related data, and (b) help providers guide patients to better self-management in real-time, especially at times when guidance is urgently needed.

4.7 Conclusions

While clinicians saw the value of patient-generated data for guiding decision making and self-management of diabetes, concerns around data responsibility, reliability, and potential disparities in care were raised. As consumer tools and aggregate data become increasingly popular for diabetes clinical management and are integrated into care delivery, it is important to

address current gaps in our understanding of how best to use various mHealth technologies and how their aggregate data can best support diabetes management.

5 Conclusion

This dissertation aimed to explore the barriers, facilitators, and user preferences of digital health use for diabetes self-management among Black men while also investigating clinicians' perspectives of digital health use for clinical decision making and management of diabetes. This dissertation is composed of Chapter Two, a qualitative study evaluating the barriers and facilitators to digital health use for self-management of diabetes among Black men; Chapter Three, a qualitative study investigating the desired design requirements for a diabetes self-management app among Black men living with diabetes with Black men as the key stakeholders; and Chapter Four, a qualitative study evaluating clinicians' perspectives of the utility of patient generated health data to guide clinical decision making and self-management of diabetes. Chapter five provides an overall review of the key findings, a discussion on the implications of the research, study limitations, and directions for future research.

5.1 Summary of Results and Key Findings

Chapter Two

The qualitative study described in Chapter Two aimed to evaluate the barriers and facilitators to digital health use for self-management of diabetes among Black men. The study results emphasized the significance of

incorporating features that enhance diabetes self-management to increase technology adoption and use, enhancing access to information and insurance coverage, and recognizing the importance of cultural values and practices when designing health technology. Participants also highlighted the importance of addressing the physical and psychological discomfort associated with technology and considering the healthcare providers' role in the use of health technology.

Chapter Three

The qualitative study described in Chapter Three aimed to investigate desired design requirements for a diabetes self-management app among Black men living with diabetes with Black men as the key stakeholders. Participants discussed the need for a diabetes self-management mobile application that tracks patient-generated health data, had customizable notifications, and provided tailored recommendations. It was discussed that the application should also offer two types of support, educational support, and social support. It was found that online communities can provide a supportive environment for black men with diabetes. These communities can provide a space for exchanging experiences, sharing tips and advice, and finding emotional support. Participants also shared components, such as interface design and data portability, which were important for a positive user experience.

Chapter Four

The qualitative study described in Chapter Four aimed to evaluate clinicians' perspectives of the utility of patient generated health data to guide clinical decision making and self-management of diabetes. Providers discussed their concerns around data responsibility and overwhelm, data reliability and validity, and provider reimbursement. Using patient generated data in clinical decision making and to guide patient care was generally viewed as a positive factor however there was concern about how using patient generated data to guide clinical decision making may wide health outcome disparities in patients who do not or are unable to use patient generated health data in their clinical care.

5.2 Nursing Practice and Science Implications

The findings of this dissertation have several implications for nursing practice. Nurses should ensure that the digital health tools they recommend are culturally appropriate for Black men with diabetes. This can involve ensuring that the tools are accessible, easy to use, and tailored to the specific needs and preferences of Black men. Nurses should provide education and support to patients on how to use digital health tools effectively. This can involve providing

guidance on selecting appropriate tools, demonstrating how to use the tools, and providing ongoing support and feedback.

The findings of this dissertation have several implications for nursing science. Nurses should consider integrating digital health tools into their clinical workflows to ensure that patients receive the support they need to manage their diabetes effectively. This can involve researching how to incorporate digital health tools into routine checkups, monitoring patient data remotely, and using digital health tools to communicate with patients and provide feedback. Digital health tools can provide clinicians with a wealth of data on patients' health status, behaviors, and preferences. Nursing science should research how to use patient generated health data to provide personalized care and support to patients, and how to tailor treatment plans and recommendations based on individual needs and circumstances. Furthermore, nursing science should examine theoretical frameworks that can support the integration of digital health tools into routine care, identify best practices for use of these digital health tools and best ways that nurses can support patients in use of these tools.

5.3 Health Policy Implications

The findings from this dissertation have several policy implications. Health policy should ensure that digital health tools are accessible and affordable

to all. This can involve promoting policies that incentivize the development and adoption of digital health tools and ensuring that healthcare providers are reimbursed for the use of these tools. Health policy should prioritize privacy and security in the use of digital health tools. This can involve promoting policies that require the use of secure platforms for data storage and transmission, ensuring that patients have control over their data, and establishing guidelines for the collection and use of patient data. Lastly, policy should promote evidence-based care in the use of digital health tools. This can involve promoting the development and dissemination of evidence-based guidelines for the use of digital health tools, promoting research on the effectiveness of these tools, and ensuring that clinicians have access to up-to-date information on the use of digital health tools in diabetes management.

5.4 Limitations and Strengths

There were several limitations and strengths in this dissertation. Generalizability from this research is limited. Like most qualitative studies, these studies involved a small sample size, so the findings may not be representative of the views of all Black men with diabetes (Chapter Two and Three). To counter this, we deliberately recruited a varied group of participants to ensure multiple viewpoints. It's worth mentioning that due to COVID-19 restrictions, we

conducted all chapter 2 and 3 interviews online using Zoom videoconferencing. This approach might have excluded individuals with poor digital literacy skills. Additionally, our sample of providers included clinicians from the same academic health system which may bias results (Chapter Four). Some of the provider interviews were conducted in person and some of the interviews were conducted over the phone which may have had an impact on answers. Lastly, our findings may not be generalizable or transferable to all clinicians working with patient-generated health data from patients with diabetes, however the findings offer a diverse representation of clinicians about the barriers and facilitators to use of patient-generated health data to guide clinical decision making and management of patients with diabetes.

Nevertheless, this dissertation has evident strengths. The study in Chapter Two and Three contributes, with Black men as key stakeholders, to the literature. From these studies, we have collected desired components of a mobile health app to facilitate management of diabetes, which may inform future designs of diabetes management health apps targeting minorities. We also conducted a thorough exploration of the barriers and facilitators to the use of digital health for diabetes management among Black men, which may help inform future

research about the development and implementation of digital health interventions tailored to the unique needs of this population.

5.5 Future Research

As the healthcare disparities, it is important for future research to continue to investigate digital health use for diabetes management and incorporate Black men as key stakeholders in the research process. Furthermore, future research should focus on determining the effectiveness of digital health tools in managing diabetes among Black men. This can involve conducting randomized controlled trials to compare the effectiveness of different digital health tools and interventions in improving diabetes outcomes. Future research should focus also on understanding the impact of digital health tools on health equity among Black men with diabetes. This can involve examining the extent to which digital health tools reduce health disparities and improve health outcomes among Black men and identifying ways to promote equitable access to these tools. Lastly, future research should also focus on understanding the optimal ways to integrate digital health tools into clinical workflows. This can involve examining the impact of integrating digital health tools into routine care on patient outcomes, identifying best practices for training healthcare providers on

the use of these tools, and best ways to support patients' education around digital health use for diabetes management.

Future research should consider frameworks specifically targeted towards Black men with diabetes such as the Gender-Centered Diabetes Management Ecological Framework for Black Men (Jack et al., 2010). The Gender-Centered Diabetes Management Ecological Framework for Black Men is a conceptual model that aims to provide a comprehensive and holistic approach to understanding and addressing the unique challenges and barriers that Black men face in managing diabetes, such as cultural expectations around masculinity and healthcare, as well as the impact of systemic racism and discrimination. Given the rates of diabetes and associated disparities throughout Black men in the United States, a conceptual framework that focuses cultural acceptability and gender sensitivity of diabetes self-management strategies will be appropriate to inform this dissertation concerning digital health technologies for diabetes self-management among Black men. It is important to have an advanced understanding of the sociocultural context needed to create new paradigms for health equity interventions and effective digital health technologies for bridging cultural differences.

5.6 Closing

Overall, this dissertation highlights the importance of exploring the barriers, facilitators, and user preferences of digital health use for diabetes self-management among Black men while also investigating clinicians' perspectives of digital health use for clinical decision making and management of diabetes. Digital health tools can help black men with diabetes take control of their health and manage their condition more effectively. However, it's important to ensure that these tools are accessible and culturally appropriate to ensure that Black men have access to the support they need to manage their diabetes. Furthermore, it is important that providers work to incorporate patient generated health data into their clinical decision-making process and stay up to date on relevant diabetes technologies in order to adequately support their patients with diabetes. Future research within clinical practice, policy and digital health is needed to construct, expand, and employ solutions that address these unique challenges.

Appendix A

Demographics Survey Questionnaire

Default Question Block



Digital Health & Diabetes Study

Purpose of the study

- You are being asked to take part in a study because we would like to hear about your experience as a Black man with Diabetes and your views on technology.

What do you have to do to take part in the study?

- Complete this survey (on the next page)
- Sign up for a Zoom Interview Session

Will you be paid for taking part in the study?

- Yes, you will be paid \$45 via an amazon e-gift card for participating in this survey and zoom interview.

Who should you contact if you want further information? Contact the researcher, Anna Diané, BSN, RN, by calling (919) 613-1427 or by sending an email to anna.diane@duke.edu. If you have questions, concerns, or a complaint about your involvement in a research study or your

Appendix B

Chapter Two Semi-Structured Interview Guide

Opening Prompt: Thank you for agreeing to talk with me. I really appreciate your time. I just want to hear about your experience with diabetes as a black man and how you've used technology to help manage your diabetes. My goal, inspired by my father who is a black man with diabetes is to help black with diabetes and their families, so any information you give me will be helpful. We will only talk as long as you would like. There are no right or wrong answers. Anything you tell me will be totally confidential. No one who works here at the Duke will hear anything you share with me. You can stop the interview at any time, and you do not have to answer any questions that you do not want to.

Note: Below is a semi-structured interview guide.

Opening Question:

- 1) Talk to me about when you first got diagnosed?
- 2) Tell me about how you take care of your diabetes? Walk me through an average day of managing your diabetes.
- 3) What is your experience with (*wearable technology*)
 - a. Glucometers vs CGMs?

- i. If you do not use any, would you like to use wearable technology? like Fitbit, apple watch?
 - b. (mhealth, patient portals,etc.)
 - 4) What are some of the things you like about using digital health (tools, portals,wearables) to take care of your diabetes?
 - 5) What are some of the challenges to using digital health (tools, portals, wearables) to take care of your diabetes?
 - a. What are some concerns you or someone else may have about using a technology (i.e.sensor, smartphone app) to track your diabetes?
 - 6) What has been the hardest thing about diabetes management or about managing your diabetes?
 - 7) On the survey, you indicated that you use apps to help you take care of your diabetes. Can you talk to me about that?
 - a. Do you think that using the app has allowed you to better take care of yourdiabetes?
 - 8) Could you please share with me how come you do not use a diabetes app?
 - a. If previously using, why did you stop?

b. What would make you use a diabetes management app?

9) Has your doctor ever mentioned/recommended any smartphone apps to you? Or any diabetes technologies?

10) what does the online diabetes culture mean to you?

11) How has Diabetes management impacted your mental health? Can technology be used to help with mental health?

12) Talk to me about how you have been managing your diabetes during covid? How has COVID impacted how you manage your diabetes?

Appendix C

Chapter Three Semi-Structured Interview Guide

Opening Prompt: Thank you for agreeing to talk with me. I really appreciate your time. I just want to hear about your experience with diabetes as a black man and how you've used technology to help manage your diabetes. Any information you give me will be helpful. We will only talk as long as you would like. There are no right or wrong answers. Anything you tell me will be totally confidential. No one who works here at the Duke will hear anything you share with me. You can stop the interview at any time, and you do not have to answer any questions that you do not want to.

Note: Below is a semi-structured interview guide.

- What are somethings that could be done to improve diabetes management for you?
- What would be on your wish list for diabetes management?
- If you were able to develop a technology or app to help you take care of your diabetes, what features would you want in the app to make it useful to you?
- If you were creating your ideal piece of technology or app for diabetes, what would it be?

- What would it have? What are some things it could do (functions)?
- If this was a perfect world, how do you see an app being developed for type twodiabetes for black men?
 - How should they be approached?
 - Are there things I should be considering?
- Let's say I am planning to develop a diabetes app specifically for Black Men with T2DM. So I'd like to pose the question: Is there anything you think I should consider when making the app?
- If you were creating something for another Black man recently diagnosed with T2DM, in an ideal world, what would it have?

Appendix D

Chapter Four Semi-Structured Interview Guide

Opening Prompt: Thank you for agreeing to talk with me. I really appreciate your time. I just want to hear about your experience with patient generated data and using that to guide your clinical decision making. There are no right or wrong answers. Anything you tell me will be totally confidential. No one who works here at the Duke will hear anything you share with me. You can stop the interview at any time, and you do not have to answer any questions that you do not want to.

Note: Below is a semi-structured interview guide.

- [Describe the study] We want to get your thoughts about the use of these technologies.
 - Do you feel these devices help patients with self-managing diabetes?
 - [Probe: If yes, why? If no, why not?]
 - How do you feel these devices help pts with SM?
 - Track (step count, BG, wt)
 - Record (step count, BG, wt)
 - Monitor (step count, BG, wt)
 - Increase awareness of SC BG wt

- If yes...how or why?
 - If no...how or why not?
- In what ways do you think digital health devices can be used to collaborate between patients and clinicians to improve the patient's self-management?
 - [Probe: Review all devices]
 - How do you think data from devices can be used for their Plan of care
 - Which device was most helpful?
- What barriers do you see to using mobile devices in diabetes self-management?
 - [Probe: Discuss—staffing, clinic structure, time]
- [Describe the purpose of data visualizations for diabetes management]
 - Please tell me what your thoughts are about visualizations. How do you think a data visualization would help your pts?
 - What kind of information would you like to see in a DV?
 - In what ways would a data visualization be helpful to you in your clinical decision making?

- How could these data be better visualized to inform your clinical decision making? [Probe: Colors? Graphics?]
 - Integrated into Point of Care?
- What changes or additions would you make?
- How can you use the patient-generated healthcare data that is generated using these real-time devices?
 - How would these inform how you communicate with your patient about their diabetes self-management? Would you use visualizations like these to enhance provider- patient communication? Do you see this strategy as an effective way to increase self-management?
 - What would be the best way to integrate this into the EHR?
 - What mHealth strategies do you see as effective ways to increase engagement?
- What implementation barriers do you see to using real-time data in your clinical decision making?
- Is there anything that you would like to mention that I didn't ask/inquire about?

- Ask if any of their patients use wearables
 - If so, which patients?
 - Ask about facilitators to using wearables; barriers?

Appendix E

Recruitment Materials

Volunteers Needed: Black Men with Diabetes

DUKE UNIVERSITY
RESEARCH STUDY



We want to hear how you use technology to manage your diabetes.

You will be compensated for your participation.

You May Qualify If You:

- Identify as Male, 18 years or older
- Identify as Black, African-American, or African/Caribbean Descent
- Have Type 1 or 2 Diabetes

Participation Involves:

- An online survey ~ 10 min to complete
- A follow-up Zoom interview

SCAN THE QR CODE TO GET STARTED



Or, visit us online at: bit.ly/T2DMhealth



For more information, contact:
anna.diane@duke.edu or call (919) 613-1427

 Duke University School of Nursing
Duke IRB: Pro00105175

References

- ADA. (2022). Statistics About Diabetes | ADA. <https://diabetes.org/about-us/statistics/about-diabetes>
- Adu, M. D., Malabu, U. H., Malau-Aduli, A. E. O., & Malau-Aduli, B. S. (2019). Enablers and barriers to effective diabetes self-management: A multi-national investigation. *PLoS ONE*, 14(6), e0217771. <https://doi.org/10.1371/journal.pone.0217771>
- Ali, E. E., Chew, L., & Yap, K. Y.-L. (2016). Evolution and current status of mhealth research: A systematic review. *BMJ Innovations*, 2(1). <https://doi.org/10.1136/bmjinnov-2015-000096>
- American Diabetes Association (2019). 6. Glycemic Targets: Standards of Medical Care in Diabetes-2019. *Diabetes care*, 42(Suppl 1), S61–S70. <https://doi.org/10.2337/dc19-S006>
- American Heart Association. (2022). The challenge of diabetes in the Black community needs comprehensive solutions. *Www.Heart.Org*. <https://www.heart.org/en/news/2021/07/13/the-challenge-of-diabetes-in-the-black-community-needs-comprehensive-solutions>
- Ashrafzadeh, S., & Hamdy, O. (2019). Patient-Driven Diabetes Care of the Future in the Technology Era. *Cell Metabolism*, 29(3), 564–575. <https://doi.org/10.1016/j.cmet.2018.09.005>
- Assari, S., Lee, D. B., Nicklett, E. J., Moghani Lankarani, M., Piette, J. D., & Aikens, J. E. (2017). Racial Discrimination in Health Care Is Associated with Worse Glycemic Control among Black Men but Not Black Women with Type 2 Diabetes. *Frontiers in Public Health*, 5. <https://www.frontiersin.org/articles/10.3389/fpubh.2017.00235>
- Austin, E., Lee, J. R., Amtmann, D., Bloch, R., Lawrence, S. O., McCall, D., Munson, S., & Lavalley, D. C. (2019). Use of patient-generated health data across healthcare settings: implications for health systems. *JAMIA open*, 3(1), 70–76. <https://doi.org/10.1093/jamiaopen/ooz065>
- Azami, G., Soh, K. L., Sazlina, S. G., Salmiah, M. S., Aazami, S., Mozafari, M., & Taghinejad, H. (2018). Effect of a Nurse-Led Diabetes Self-Management

Education Program on Glycosylated Hemoglobin among Adults with Type 2 Diabetes. *Journal of Diabetes Research*, 2018, 4930157. <https://doi.org/10.1155/2018/4930157>

Azelton, K. R., Crowley, A. P., Vence, N., Underwood, K., Morris, G., Kelly, J., & Landry, M. J. (2021). Digital Health Coaching for Type 2 Diabetes: Randomized Controlled Trial of Healthy at Home. *Frontiers in Digital Health*, 3. <https://www.frontiersin.org/articles/10.3389/fdgth.2021.764735>

Bekele, B. B., Negash, S., Bogale, B., Tesfaye, M., Getachew, D., Weldekidan, F., & Balcha, B. (2021). Effect of diabetes self-management education (DSME) on glycosylated hemoglobin (HbA1c) level among patients with T2DM: Systematic review and meta-analysis of randomized controlled trials. *Diabetes & Metabolic Syndrome*, 15(1), 177–185. <https://doi.org/10.1016/j.dsx.2020.12.030>

Bengtsson, M. (2016). How to plan and perform a qualitative study using content analysis. *NursingPlus Open*, 2, 8–14. <https://doi.org/10.1016/j.npls.2016.01.001>

Bode, B., King, A., Russell-Jones, D., & Billings, L. K. (2021). Leveraging advances in diabetes technologies in primary care: A narrative review. *Annals of Medicine*, 53(1), 805–816. <https://doi.org/10.1080/07853890.2021.1931427>

Bonet Olivencia, S., Rao, A. H., Smith, A., & Sasangohar, F. (2021). Eliciting Requirements for a Diabetes Self-Management Application for Underserved Populations: A Multi-Stakeholder Analysis. *International Journal of Environmental Research and Public Health*, 19(1), 127. <https://doi.org/10.3390/ijerph19010127>

Boussageon, R., Pouchain, D., & Renard, V. (2017). Prevention of complications in type 2 diabetes: Is drug glucose control evidence based? *The British Journal of General Practice*, 67(655), 85–87. <https://doi.org/10.3399/bjgp17X689317>

Boyle, J. P., Thompson, T. J., Gregg, E. W., Barker, L. E., & Williamson, D. F. (2010). Projection of the year 2050 burden of diabetes in the US adult population: dynamic modeling of incidence, mortality, and prediabetes prevalence. 8(1), 29. doi:10.1186/1478-7954-8-29

- Brunisholz, K. D., Briot, P., Hamilton, S., Joy, E. A., Lomax, M., Barton, N., Cunningham, R., Savitz, L. A., & Cannon, W. (2014). Diabetes self-management education improves quality of care and clinical outcomes determined by a diabetes bundle measure. *Journal of Multidisciplinary Healthcare*, 7, 533–542. <https://doi.org/10.2147/JMDH.S69000>
- Bults, M., van Leersum, C. M., Olthuis, T. J., Bekhuis, R. M., & den Ouden, M. E. (2021). Barriers and Drivers Regarding the Use of Mobile Health Apps Among Patients With Type 2 Diabetes Mellitus in the Netherlands: Explanatory Sequential Design Study. *JMIR Diabetes*, 7(1), 1-7.
- Byambasuren, O., Sanders, S., Beller, E., & Glasziou, P. (2018). Prescribable mHealth apps identified from an overview of systematic reviews. *Npj Digital Medicine*, 1(1), Article 1. <https://doi.org/10.1038/s41746-018-0021-9>
- Byers, D., Garth, K., Manley, D., & Chlebowy, D. (2016). Facilitators and Barriers to Type 2 Diabetes Self-Management Among Rural African American Adults. *Journal of HDRP*, 9(1).
- Carmienke, S., Baumert, J., Gabrys, L., Heise, M., Frese, T., Heidemann, C., & Fink, A. (2020). Participation in structured diabetes mellitus self-management education program and association with lifestyle behavior: Results from a population-based study. *BMJ Open Diabetes Research & Care*, 8(1), e001066. <https://doi.org/10.1136/bmjdr-2019-001066>
- Carthron, D., McCullough, W., Chatterjee, S., Key, K., Lemke, K., Gordon, D., Piatt, G., & Neighbors, H. (2021). Self-Management of Diabetes in Black Men: The Flint MANUP Intervention Study. *Innovation in Aging*, 5(Supplement_1), 397–398. <https://doi.org/10.1093/geroni/igab046.1546>
- CDC. (2022). From the CDC-Leading Causes of Death-Males all races and origins 2018. Centers for Disease Control and Prevention. <https://www.cdc.gov/minorityhealth/lcod/men/2018/nonhispanic-black/index.htm>
- Centers for Disease Control and Prevention. National Diabetes Statistics Report: Estimates of Diabetes and Its Burden in the United States, 2022a. Atlanta: US Department of Health and Human Services; 2022. Accessed on January

1, 2023 from <https://www.cdc.gov/diabetes/data/statistics-report/index.html>

- Chang, R., Javed, Z., Taha, M., Yahya, T., Valero-Elizondo, J., Brandt, E. J., Cainzos-Achirica, M., Mahajan, S., Ali, H. J., & Nasir, K. (2021). Food insecurity and cardiovascular disease: Current trends and future directions. *American journal of preventive cardiology*, 9, 100303. <https://doi.org/10.1016/j.ajpc.2021.100303>
- Chlebowy, D. O., Hood, S., & LaJoie, A. S. (2010). Facilitators and barriers to self-management of type 2 diabetes among urban African American adults: focus group findings. *Diabetes Educ*, 36(6), 897-905. doi:10.1177/0145721710385579
- Chlebowy, D. O., Hood, S., & LaJoie, A. S. (2013). Gender differences in diabetes self-management among African American adults. *West J Nurs Res*, 35(6), 703-721. doi:10.1177/0193945912473370
- Chung, C. F., Cook, J., Bales, E., Zia, J., & Munson, S. A. (2015). More Than Telemonitoring: Health Provider Use and Nonuse of Life-Log Data in Irritable Bowel Syndrome and Weight Management. *Journal of medical Internet research*, 17(8), e203. <https://doi.org/10.2196/jmir.4364>
- Cohen, D. J., Keller, S. R., Hayes, G. R., Dorr, D. A., Ash, J. S., & Sittig, D. F. (2016). Integrating Patient-Generated Health Data Into Clinical Care Settings or Clinical Decision-Making: Lessons Learned From Project HealthDesign. *JMIR human factors*, 3(2), e26. <https://doi.org/10.2196/humanfactors.5919>
- Cope, D. G. (2014). Methods and meanings: credibility and trustworthiness of qualitative research. *Oncology Nursing Forum*, 41(1), 89-91. doi:10.1188/14.onf.89-91
- Creswell, J. W., & Plano Clark, V. L. (2017). *Designing and conducting mixed methods research* (3rd ed.). SAGE Publications.
- Demiris, G., Iribarren, S. J., Sward, K., Lee, S., & Yang, R. (2019). Patient generated health data use in clinical practice: A systematic review. *Nursing outlook*, 67(4), 311-330. <https://doi.org/10.1016/j.outlook.2019.04.005>

- Donnelly, S. C. (2020). Digital Health Solutions—The future—But not quite yet | Request PDF. *QJM: An International Journal of Medicine*, 113(3), 153–154. <https://doi.org/doi.org/10.1093/qjmed/hcaa023>
- Doyle-Delgado, K., & Chamberlain, J. J. (2020). Use of Diabetes-Related Applications and Digital Health Tools by People With Diabetes and Their Health Care Providers. *Clinical Diabetes : A Publication of the American Diabetes Association*, 38(5), 449–461. <https://doi.org/10.2337/cd20-0046>
- Dugas, M., Gao, G. (Gordon), & Agarwal, R. (2020). Unpacking mHealth interventions: A systematic review of behavior change techniques used in randomized controlled trials assessing mHealth effectiveness. *Digital Health*, 6, 2055207620905411. <https://doi.org/10.1177/2055207620905411>
- Ehrmann, D., Eichinger, V., Vesper, I., Kober, J., Kraus, M., Schäfer, V., Hermanns, N., Kulzer, B., & Silbermann, S. (2022). Health care effects and medical benefits of a smartphone-based diabetes self-management application: Study protocol for a randomized controlled trial. *Trials*, 23(1), 282. <https://doi.org/10.1186/s13063-022-06248-2>
- Elo, S., & Kyngas, H. (2008). The qualitative content analysis process. *J Adv Nurs*, 62(1), 107-115. doi:10.1111/j.1365-2648.2007.04569.x
- Ernawati, U., Wihastuti, T. A., & Utami, Y. W. (2021). Effectiveness of diabetes self-management education (DSME) in type 2 diabetes mellitus (T2DM) patients: Systematic literature review. *Journal of Public Health Research*, 10(2), 2240. <https://doi.org/10.4081/jphr.2021.2240>
- Fleming, G. A., Petrie, J. R., Bergenstal, R. M., Holl, R. W., Peters, A. L., & Heinemann, L. (2019). Diabetes Digital App Technology: Benefits, Challenges, and Recommendations. A Consensus Report by the European Association for the Study of Diabetes (EASD) and the American Diabetes Association (ADA) Diabetes Technology Working Group. *Diabetes Care*, 43(1), 250–260. <https://doi.org/10.2337/dci19-0062>
- Foong, H. F., Kyaw, B. M., Upton, Z., & Tudor Car, L. (2020). Facilitators and barriers of using digital technology for the management of diabetic foot ulcers: A qualitative systematic review. *International Wound Journal*, 17(5), 1266–1281. <https://doi.org/10.1111/iwj.13396>

- Fortuin, J., Salie, F., Abdullahi, L. H., & Douglas, T. S. (2016). The impact of mHealth interventions on health systems: A systematic review protocol. *Systematic Reviews*, 5(1), 200. <https://doi.org/10.1186/s13643-016-0387-1>
- Giordanengo, A., Årsand, E., Woldaregay, A. Z., Bradway, M., Grottnland, A., Hartvigsen, G., Granja, C., Torsvik, T., & Hansen, A. H. (2019). Design and Prestudy Assessment of a Dashboard for Presenting Self-Collected Health Data of Patients With Diabetes to Clinicians: Iterative Approach and Qualitative Case Study. *JMIR diabetes*, 4(3), e14002. <https://doi.org/10.2196/14002>
- Golden, S. H., Brown, A., Cauley, J. A., Chin, M. H., Gary-Webb, T. L., Kim, C., Sosa, J. A., Sumner, A. E., & Anton, B. (2012). Health disparities in endocrine disorders: biological, clinical, and nonclinical factors--an Endocrine Society scientific statement. *The Journal of clinical endocrinology and metabolism*, 97(9), E1579–E1639. <https://doi.org/10.1210/jc.2012-2043>
- Grande, S. W., & Sherman, L. D. (2018). Too Important to Ignore: Leveraging Digital Technology to Improve Chronic Illness Management Among Black Men. *Journal of medical Internet research*, 20(5), e182. <https://doi.org/10.2196/jmir.9434>
- Graneheim, U. H., & Lundman, B. (2004). Qualitative content analysis in nursing research: concepts, procedures and measures to achieve trustworthiness. *Nurse Educ Today*, 24(2), 105-112. doi:10.1016/j.nedt.2003.10.001
- Greenwood, D. A., Gee, P. M., Fatkin, K. J., & Peeples, M. (2017). A Systematic Review of Reviews Evaluating Technology-Enabled Diabetes Self-Management Education and Support. *Journal of diabetes science and technology*, 11(5), 1015–1027. <https://doi.org/10.1177/1932296817713506>
- Hailu, F. B., Moen, A., & Hjortdahl, P. (2019). Diabetes Self-Management Education (DSME) - Effect on Knowledge, Self-Care Behavior, and Self-Efficacy Among Type 2 Diabetes Patients in Ethiopia: A Controlled Clinical Trial. *Diabetes, Metabolic Syndrome and Obesity: Targets and Therapy*, 12, 2489–2499. <https://doi.org/10.2147/DMSO.S223123>
- Hartz, J., Yingling, L., & Powell-Wiley, T. M. (2016). Use of Mobile Health Technology in the Prevention and Management of Diabetes Mellitus.

- Current cardiology reports, 18(12), 130. <https://doi.org/10.1007/s11886-016-0796-8>
- Hawkins, J. M. (2019). Type 2 Diabetes Self-Management in Non-Hispanic Black Men: A Current State of the Literature. *Current Diabetes Reports*, 19(3), 10. <https://doi.org/10.1007/s11892-019-1131-8>
- Hawkins, J., Sengupta, S., Kloss, K. A., Kurnick, K., Ewen, A., Nwawkwo, R., Funnell, M., Mitchell, J., Jones, L., & Piatt, G. (2022). Michigan men's diabetes project II: Protocol for peer-led diabetes self-management education and long-term support in Black men [Preprint]. *Public and Global Health*. <https://doi.org/10.1101/2022.11.03.22281893>
- HHS.gov. (2021). Diabetes and African Americans—The Office of Minority Health. <https://minorityhealth.hhs.gov/omh/browse.aspx?lvl=4&lvlid=18>
- Hill-Briggs, F., Adler, N. E., Berkowitz, S. A., Chin, M. H., Gary-Webb, T. L., Navas-Acien, A., Thornton, P. L., & Haire-Joshu, D. (2020). Social Determinants of Health and Diabetes: A Scientific Review. *Diabetes care*, 44(1), 258–279. Advance online publication. <https://doi.org/10.2337/dci20-0053>
- Hou, C., Xu, Q., Diao, S., Hewitt, J., Li, J., & Carter, B. (2018). Mobile phone applications and self-management of diabetes: A systematic review with meta-analysis, meta-regression of 21 randomized trials and GRADE. *Diabetes, Obesity & Metabolism*, 20(8), 2009–2013. <https://doi.org/10.1111/dom.13307>
- Hsieh, H. F., & Shannon, S. E. (2005). Three approaches to qualitative content analysis. *Qual Health Res*, 15(9), 1277-1288. doi:10.1177/1049732305276687
- Hughes, A., Shandhi, M. M. H., Master, H., Dunn, J., & Brittain, E. (2023). Wearable Devices in Cardiovascular Medicine. *Circulation research*, 132(5), 652–670. <https://doi.org/10.1161/CIRCRESAHA.122.322389>
- Hurt, T. R., Francis, S. L., Seawell, A. H., Krisco, M. P., Flynn, M. H., O'Connor, M. C., Rudolph, C. S., & Hill, A. (2020). Revising Diabetes Programming for Black Men and Their Families. *Global Qualitative Nursing Research*, 7, 2333393620960183. <https://doi.org/10.1177/2333393620960183>

- Hurt, T. R., Seawell, A. H., & O'Connor, M. C. (2015). Developing Effective Diabetes Programming for Black Men. *Global qualitative nursing research*, 2, 2333393615610576. <https://doi.org/10.1177/2333393615610576>
- Ida, S., Kaneko, R., & Murata, K. (2019). Utility of Real-Time and Retrospective Continuous Glucose Monitoring in Patients with Type 2 Diabetes Mellitus: A Meta-Analysis of Randomized Controlled Trials. *Journal of diabetes research*, 2019, 4684815. <https://doi.org/10.1155/2019/4684815>
- Iyengar, V., Wolf, A., Brown, A., & Close, K. (2016). Challenges in Diabetes Care: Can Digital Health Help Address Them? *Clinical Diabetes : A Publication of the American Diabetes Association*, 34(3), 133–141. <https://doi.org/10.2337/diaclin.34.3.133>
- Jack, L., Jr, Toston, T., Jack, N. H., & Sims, M. (2010). A gender-centered ecological framework targeting Black men living with diabetes: integrating a “masculinity” perspective in diabetes management and education research. *American journal of men’s health*, 4(1), 7–15. <https://doi.org/10.1177/1557988308321956>
- Jeffrey, B., Bagala, M., Creighton, A., Leavey, T., Nicholls, S., Wood, C., Longman, J., Barker, J., & Pit, S. (2019). Mobile phone applications and their use in the self-management of Type 2 Diabetes Mellitus: A qualitative study among app users and non-app users. *Diabetology & Metabolic Syndrome*, 11(1), 84. <https://doi.org/10.1186/s13098-019-0480-4>
- Kargar Jahromi, M., Ramezanli, S., & Taheri, L. (2014). Effectiveness of diabetes self-management education on quality of life in diabetic elderly females. *Global Journal of Health Science*, 7(1), 10–15. <https://doi.org/10.5539/gjhs.v7n1p10>
- Kebede, M. M., & Pischke, C. R. (2019). Popular Diabetes Apps and the Impact of Diabetes App Use on Self-Care Behaviour: A Survey Among the Digital Community of Persons With Diabetes on Social Media. *Frontiers in Endocrinology*, 10, 135. <https://doi.org/10.3389/fendo.2019.00135>
- Kerr, D., Klonoff, D. C., Bergenstal, R. M., Choudhary, P., & Ji, L. (2022). A Roadmap to an Equitable Digital Diabetes Ecosystem. *Endocrine Practice: Official Journal of the American College of Endocrinology and the*

American Association of Clinical Endocrinologists, S1530-891X(22)00908-9. <https://doi.org/10.1016/j.eprac.2022.12.016>

Kieu, A., King, J., Govender, R. D., & Östlundh, L. (2022). The Benefits of Utilizing Continuous Glucose Monitoring of Diabetes Mellitus in Primary Care: A Systematic Review. *Journal of diabetes science and technology*, 19322968211070855. Advance online publication. <https://doi.org/10.1177/19322968211070855>

Kim, H., Sefcik, J. S., & Bradway, C. (2017). Characteristics of Qualitative Descriptive Studies: A Systematic Review. *Research in Nursing & Health*, 40(1), 23–42. <https://doi.org/10.1002/nur.21768>

Kitsiou, S., Paré, G., Jaana, M., & Gerber, B. (2017). Effectiveness of mHealth interventions for patients with diabetes: An overview of systematic reviews. *PloS One*, 12(3), e0173160. <https://doi.org/10.1371/journal.pone.0173160>

Lavallee, D. C., Lee, J. R., Austin, E., Bloch, R., Lawrence, S. O., McCall, D., ... & Amtmann, D. (2020). mHealth and patient generated health data: stakeholder perspectives on opportunities and barriers for transforming healthcare. *Mhealth*, 6.

Lewinski, A. A., Drake, C., Shaw, R. J., Jackson, G. L., Bosworth, H. B., Oakes, M., Gonzales, S., Jelesoff, N. E., & Crowley, M. J. (2019). Bridging the integration gap between patient-generated blood glucose data and electronic health records. *Journal of the American Medical Informatics Association : JAMIA*, 26(7), 667–672. <https://doi.org/10.1093/jamia/ocz039>

Liburd, L. C., Namageyo-Funa, A., & Jack, L., Jr (2007). Understanding "masculinity" and the challenges of managing type-2 diabetes among African-American men. *Journal of the National Medical Association*, 99(5), 550–558.

Lincoln and Guba, 1985, Y. Lincoln, E. Guba, *Naturalistic inquiry*, 1985, SAGE, Beverly Hills, CA

Maiorino, M. I., Signoriello, S., Maio, A., Chiodini, P., Bellastella, G., Scappaticcio, L., Longo, M., Giugliano, D., & Esposito, K. (2020). Effects of Continuous Glucose Monitoring on Metrics of Glycemic Control in

Diabetes: A Systematic Review With Meta-analysis of Randomized Controlled Trials. *Diabetes care*, 43(5), 1146–1156.
<https://doi.org/10.2337/dc19-1459>

Manti, S., & Licari, A. (2018). How to obtain informed consent for research. *Breathe*, 14(2), 145–152. <https://doi.org/10.1183/20734735.001918>

Mao, Y., Lin, W., Wen, J., & Chen, G. (2020). Impact and efficacy of mobile health intervention in the management of diabetes and hypertension: A systematic review and meta-analysis. *BMJ Open Diabetes Research and Care*, 8(1), e001225. <https://doi.org/10.1136/bmjdr-2020-001225>

Marcolino, M. S., Oliveira, J. A. Q., D'Agostino, M., Ribeiro, A. L., Alkmim, M. B. M., & Novillo-Ortiz, D. (2018). The Impact of mHealth Interventions: Systematic Review of Systematic Reviews. *JMIR MHealth and UHealth*, 6(1), e23. <https://doi.org/10.2196/mhealth.8873>

Marincic, P. Z., Salazar, M. V., Hardin, A., Scott, S., Fan, S. X., Gaillard, P. R., Wyatt, C., Watson, L., Green, P., Glover, P., & Hand, M. (2019). Diabetes Self-Management Education and Medical Nutrition Therapy: A Multisite Study Documenting the Efficacy of Registered Dietitian Nutritionist Interventions in the Management of Glycemic Control and Diabetic Dyslipidemia through Retrospective Chart Review. *Journal of the Academy of Nutrition and Dietetics*, 119(3), 449–463.
<https://doi.org/10.1016/j.jand.2018.06.303>

Miles, M. B., Huberman, A. M., Huberman, M. A., & Huberman, P. M. (1994). *Qualitative Data Analysis: An Expanded Sourcebook*: SAGE Publications.

Morse, J. M. (2015). Critical Analysis of Strategies for Determining Rigor in Qualitative Inquiry. *Qual Health Res*, 25(9), 1212-1222.
[doi:10.1177/1049732315588501](https://doi.org/10.1177/1049732315588501)

Newton, R. L., Jr, Griffith, D. M., Kearney, W. B., & Bennett, G. G. (2014). A systematic review of weight loss, physical activity and dietary interventions involving African American men. *Obesity reviews : an official journal of the International Association for the Study of Obesity*, 15 Suppl 4, 93–106. <https://doi.org/10.1111/obr.12209>

- Nittas, V., Lun, P., Ehrler, F., Puhan, M. A., & Mütsch, M. (2019). Electronic Patient-Generated Health Data to Facilitate Disease Prevention and Health Promotion: Scoping Review. *Journal of medical Internet research*, 21(10), e13320. <https://doi.org/10.2196/13320>
- Nundy, S., Dick, J. J., Chou, C.-H., Nocon, R. S., Chin, M. H., & Peek, M. E. (2014). Mobile phone diabetes project led to improved glycemic control and net savings for Chicago plan participants. *Health Affairs (Project Hope)*, 33(2), 265–272. <https://doi.org/10.1377/hlthaff.2013.0589>
- Osborn, C. Y., de Groot, M., & Wagner, J. A. (2013). Racial and ethnic disparities in diabetes complications in the northeastern United States: the role of socioeconomic status. *Journal of the National Medical Association*, 105(1), 51–58. [https://doi.org/10.1016/s0027-9684\(15\)30085-7](https://doi.org/10.1016/s0027-9684(15)30085-7)
- Pew Research Center. (2021). Mobile Fact Sheet. Pew Research Center: Internet, Science & Tech. <https://www.pewresearch.org/internet/fact-sheet/mobile/>
- Piccinino, L., Griffey, S., Gallivan, J., Lotenberg, L. D., & Tuncer, D. (2015). Recent Trends in Diabetes Knowledge, Perceptions, and Behaviors: Implications for National Diabetes Education. *Health Education & Behavior*, 42(5), 687–696. doi:10.1177/1090198115577373
- Piette, J. D., Bibbins-Domingo, K., & Schillinger, D. (2006). Health care discrimination, processes of care, and diabetes patients' health status. *Patient Education and Counseling*, 60(1), 41–48. <https://doi.org/10.1016/j.pec.2004.12.001>
- Powers, M. A., Bardsley, J., Cypress, M., Duker, P., Funnell, M. M., Fischl, A. H., Maryniuk, M. D., Siminerio, L., & Vivian, E. (2016). Diabetes Self-management Education and Support in Type 2 Diabetes: A Joint Position Statement of the American Diabetes Association, the American Association of Diabetes Educators, and the Academy of Nutrition and Dietetics. *Clinical Diabetes : A Publication of the American Diabetes Association*, 34(2), 70–80. <https://doi.org/10.2337/diaclin.34.2.70>
- Qayyum, A. A., Lone, S. W., Ibrahim, M. N., Atta, I., & Raza, J. (2010). Effects of diabetes self-management education on glycaemic control in children with insulin-dependent diabetes mellitus. *Journal of the College of Physicians and Surgeons--Pakistan: JCPSP*, 20(12), 802–805.

- Qudah, B., & Luetsch, K. (2019). The influence of mobile health applications on patient – healthcare provider relationships: A systematic, narrative review. *Patient education and counseling*, 102(6), 1080–1089. <https://doi.org/10.1016/j.pec.2019.01.021>
- Randolph, S., Coakley, T., & Shears, J. (2018). Recruiting and engaging African-American men in health research. *Nurse researcher*, 26(1), 8–12. <https://doi.org/10.7748/nr.2018.e1569>
- Ricci-Cabello, I., Ruiz-Pérez, I., Nevot-Cordero, A., Rodríguez-Barranco, M., Sordo, L., & Gonçalves, D. C. (2013). Health care interventions to improve the quality of diabetes care in African Americans: a systematic review and meta-analysis. *Diabetes care*, 36(3), 760–768. <https://doi.org/10.2337/dc12-1057>
- Rodbard D. (2016). Continuous Glucose Monitoring: A Review of Successes, Challenges, and Opportunities. *Diabetes technology & therapeutics*, 18 Suppl 2(Suppl 2), S3–S13. <https://doi.org/10.1089/dia.2015.0417>
- Rusdiana, null, Savira, M., & Amelia, R. (2018). The Effect of Diabetes Self-Management Education on Hba1c Level and Fasting Blood Sugar in Type 2 Diabetes Mellitus Patients in Primary Health Care in Binjai City of North Sumatera, Indonesia. *Open Access Macedonian Journal of Medical Sciences*, 6(4), 715–718. <https://doi.org/10.3889/oamjms.2018.169>
- Ryan, A. M., Gee, G. C., & Griffith, D. (2008). The effects of perceived discrimination on diabetes management. *Journal of Health Care for the Poor and Underserved*, 19(1), 149–163. <https://doi.org/10.1353/hpu.2008.0005>
- Sandelowski M. (2000). Whatever happened to qualitative description?. *Research in nursing & health*, 23(4), 334–340. [https://doi.org/10.1002/1098-240x\(200008\)23:4<334::aid-nur9>3.0.co;2-g](https://doi.org/10.1002/1098-240x(200008)23:4<334::aid-nur9>3.0.co;2-g)
- Sezgin, E., Özkan-Yildirim, S., & Yildirim, S. (2018). Understanding the perception towards using mHealth applications in practice: Physicians' perspective. *Information Development*, 34(2), 182–200. <https://doi.org/10.1177/0266666916684180>

- Shan, R., Sarkar, S., & Martin, S. S. (2019). Digital health technology and mobile devices for the management of diabetes mellitus: state of the art. *Diabetologia*, 62(6), 877–887. <https://doi.org/10.1007/s00125-019-4864-7>
- Shapiro, M., Johnston, D., Wald, J., & Mon, D. (2012). Patient generated health data: White Paper. Retrieved from Research Triangle Park, NC: https://www.healthit.gov/sites/default/files/rti_pghd_whitepaper_april_2012.pdf.
- Shaw, R. J., & Ferranti, J. (2011). Patient-provider internet portals--patient outcomes and use. *Computers, informatics, nursing : CIN*, 29(12), 714–720. <https://doi.org/10.1097/NCN.0b013e318224b597>
- Shaw, R. J., Barnes, A., Steinberg, D., Vaughn, J., Diane, A., Levine, E., . . . Yang, Q. (2019). Enhancing Diabetes Self-Management Through Collection and Visualization of Data From Multiple Mobile Health Technologies: Protocol for a Development and Feasibility Trial. *JMIR Res Protoc*, 8(6), e13517. doi:10.2196/13517
- Shaw, R. J., Yang, Q., Barnes, A., Hatch, D., Crowley, M. J., Vorderstrasse, A., Vaughn, J., Diane, A., Lewinski, A. A., Jiang, M., Stevenson, J., & Steinberg, D. (2020). Self-monitoring diabetes with multiple mobile health devices. *Journal of the American Medical Informatics Association : JAMIA*, 27(5), 667–676. <https://doi.org/10.1093/jamia/ocaa007>
- Sherman, L. D., Hawkins, J. M., & Bonner, T. (2017). An Analysis of the Recruitment and Participation of African American Men in Type 2 Diabetes Self-Management Research: A Review of the Published Literature. *Social work in public health*, 32(1), 38–48. <https://doi.org/10.1080/19371918.2016.1188742>
- Shi, C., Zhu, H., Liu, J., Zhou, J., & Tang, W. (2020). Barriers to Self-Management of Type 2 Diabetes During COVID-19 Medical Isolation: A Qualitative Study. *Diabetes, Metabolic Syndrome and Obesity: Targets and Therapy*, 13, 3713–3725. <https://doi.org/10.2147/DMSO.S268481>
- Smith, M. B., Albanese-O'Neill, A., Macieira, T. G. R., Yao, Y., Abbatematteo, J. M., Lyon, D., Wilkie, D. J., Haller, M. J., & Keenan, G. M. (2019). Human Factors Associated with Continuous Glucose Monitor Use in Patients with

- Diabetes: A Systematic Review. *Diabetes technology & therapeutics*, 21(10), 589–601. <https://doi.org/10.1089/dia.2019.0136>
- Tiase, V. L., Hull, W., McFarland, M. M., Sward, K. A., Del Fiol, G., Staes, C., Weir, C., & Cummins, M. R. (2020). Patient-generated health data and electronic health record integration: a scoping review. *JAMIA open*, 3(4), 619–627. <https://doi.org/10.1093/jamiaopen/ooaa052>
- Torres-Ruiz, M., Robinson-Ector, K., Atkinson, D., Trotter, J., Anise, A., & Clauser, S. (2018). A Portfolio Analysis of Culturally Tailored Trials to Address Health and Healthcare Disparities. *International journal of environmental research and public health*, 15(9), 1859. <https://doi.org/10.3390/ijerph15091859>
- Trivedi, A. N., & Ayanian, J. Z. (2006). Perceived Discrimination and Use of Preventive Health Services. *Journal of General Internal Medicine*, 21(6), 553. <https://doi.org/10.1111/j.1525-1497.2006.00413.x>
- US Department of Health & Human Services (HHS). Consumer eHealth: Patient-Generated Health Data 2015. Available online: <https://www.healthit.gov/policy-researchers/implementers/patient-generated-health-data>
- van Ommen, B., Wopereis, S., van Empelen, P., van Keulen, H. M., Otten, W., Kasteleyn, M., Molema, J. J. W., de Hoogh, I. M., Chavannes, N. H., Numans, M. E., Evers, A. W. M., & Pijl, H. (2017). From Diabetes Care to Diabetes Cure-The Integration of Systems Biology, eHealth, and Behavioral Change. *Frontiers in Endocrinology*, 8, 381. <https://doi.org/10.3389/fendo.2017.00381>
- Veinot, T. C., Mitchell, H., & Ancker, J. S. (2018). Good intentions are not enough: how informatics interventions can worsen inequality. *Journal of the American Medical Informatics Association: JAMIA*, 25(8), 1080–1088. <https://doi.org/10.1093/jamia/ocy052>
- Villalobos, N., Vela, F. S., & Hernandez, L. M. (2020). Digital Healthcare Intervention to Improve Self-Management for Patients with Type 2 Diabetes: A Scoping Review. *Journal of Scientific Innovation in Medicine*, 3(3), Article 3. <https://doi.org/10.29024/jsim.78>

- Whitelaw, S., Pellegrini, D. M., Mamas, M. A., Cowie, M., & Van Spall, H. G. C. (2021). Barriers and facilitators of the uptake of digital health technology in cardiovascular care: A systematic scoping review. *European Heart Journal - Digital Health*, 2(1), 62–74. <https://doi.org/10.1093/ehjdh/ztab005>
- Whittemore, R., Chase, S., & Mandle, C. (2001). Validity in Qualitative Research. *Qualitative Health Research*, 11(4), 522-537. doi:10.1177/104973201129119299
- Williams, D. R. (2008). The Health of Men: Structured Inequalities and Opportunities. *American Journal of Public Health*, 98(Suppl 1), S150–S157.
- Yoon, S., Kwan, Y. H., Phang, J. K., Tan, W. B., & Low, L. L. (2022). Personal Goals, Barriers to Self-Management and Desired mHealth Application Features to Improve Self-Care in Multi-Ethnic Asian Patients with Type 2 Diabetes: A Qualitative Study. *International Journal of Environmental Research and Public Health*, 19(22), 15415. <https://doi.org/10.3390/ijerph192215415>
- Yuan, C., Lai, C. W. K., Chan, L. W. C., Chow, M., Law, H. K. W., & Ying, M. (2014). The effect of diabetes self-management education on body weight, glycemic control, and other metabolic markers in patients with type 2 diabetes mellitus. *Journal of Diabetes Research*, 2014, 789761. <https://doi.org/10.1155/2014/789761>
- Zheng, F., Liu, S., Liu, Y., & Deng, L. (2019). Effects of an Outpatient Diabetes Self-Management Education on Patients with Type 2 Diabetes in China: A Randomized Controlled Trial. *Journal of Diabetes Research*, 2019, 1073131. <https://doi.org/10.1155/2019/1073131>

Biography

In 2012, Anna received a Bachelor of Science in Nursing from Boston College where she was awarded the “Jean O’Neil Achievement Award” and inducted into the Sigma Theta Tau International Honor Nursing of Society. She is currently a PhD candidate in the Duke University School of Nursing. Prior to beginning doctoral training, Anna worked as a registered nurse in the Liver ICU at UCLA Hospital in Los Angeles, California and as a clinical informatics analyst at NYU Langone Medical Center in New York, New York.

She is co-author on 3 manuscripts, “Enhancing diabetes self-management through collection and visualization of data from multiple mobile health technologies: Protocol for a development and feasibility”, which was published in 2019 in the Journal of JMIR Research Protocols; “Self-monitoring diabetes with multiple mobile health devices”, which was published in 2020 in the Journal of American Medical Informatics Association; and “Perceptions of Using Multiple Mobile Health Devices to Support Self-Management Among Adults With Type 2 Diabetes: A Qualitative Descriptive Study”, which was published in 2021 in the Journal of Nursing Scholarship. Anna presented two short talks, “Enabling Precision Health in Type II Diabetes through Mobile Health Technologies” in 2019 at the Digital Health: From Science to Application Keystone Symposia; and

“Innovations and the Scientific Basis of Nursing: Digital Health” in 2019 at the Athena conference at the University of Connecticut. Anna co-authored and presented 2 abstracts for presentation, “Patient Perspectives of Utilizing Multiple Mobile Health Technologies to Self-Manage Type 2 Diabetes” and “Patient Perceptions of Real-Time Data Visualizations in Diabetes Self-Management” in 2019 at the American Medical Informatics Association Annual Symposium.

In 2012, Anna was a recipient of the “Keys to Inclusive Leadership in Nursing Award” and the “Recognition for Leadership and Volunteer Service Award”. In 2017, she was a recipient of the of the James B. Duke graduate fellowship award which generously supported her doctoral training at Duke University. In 2020, Anna was the recipient of a Predoctoral Individual National Research Service Award from the National Institutes of Health, National Institute of Nursing Research.