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Effectiveness of Telemedicine in Diabetes Management: A Retrospective Study in an Urban Medically Underserved Population Area (UMUPA).

Lisa Ariellah Ward

EFFECTIVENESS OF TELEMEDICINE IN DIABETES MANAGEMENT: A RETROSPECTIVE STUDY IN AN URBAN MEDICALLY UNDERSERVED POPULATION AREA (UMUPA)

by

LISA ARIELLAH WARD

(Under the Direction of Gulzar H. Shah)

ABSTRACT

The purpose of this research is to assess the efficacy of employing telemedicine (TM) technology compared to traditional face-to-face (F2F) visits as an alternative healthcare delivery service for managing diabetes in populations residing in urban medically underserved areas (UMUPA). Researchers investigating public health and healthcare systems fully grasp the enormous challenges encountered by vulnerable populations as a result of healthcare access barriers.[1] Prior to the COVID-19 pandemic, F2F visits were most often utilized for healthcare delivery service, which frequently posed barriers for vulnerable populations. When marginalized people, encounter healthcare access barriers, a cascade of events generally occur leading to forestalling or avoiding healthcare services entirely, complicating disease management, resulting in negative health outcomes. This was a novel study examining the hemoglobin A1c (HbA1c) values of 111 patients with uncontrolled type 2 diabetes mellitus (T2DM) and 81 patients with prediabetes. Retrospective electronic patient health records (PHR) from a medical clinic were examined from January 1st, 2019 to June 30th, 2021. The results indicate that lowering HbA1c values for T2DM patients through utilizing TM is similar to outcomes from traditional visits, suggesting that TM may be an alternative mode of healthcare delivery for vulnerable populations. Results for patients with prediabetes were not statistically significant. Patients with uncontrolled diabetes and prediabetes shared a number of similar characteristics; they were predominantly Black, non-Hispanic, females, with a median age of 57 years; and resided in locations with inadequate access to healthcare services in an UMUPA. The majority of patients with uncontrolled diabetes who reside in an UMUPA completed appointments utilized TM technology, lending credence to its potential as an alternative healthcare delivery service for underserved populations. TM technology supports PH and the healthcare system with a viable, alternative strategy for expanding healthcare access where chronic illness and disease pose a significant threat to the health and wellbeing of vulnerable groups. Optimal treatment for patients with diabetes necessitates a proactive, coordinated, systems-thinking team approach. This research supports PH's endeavors in tackling the long-standing healthcare access barrier challenges in underserved populations.

INDEX WORDS: Telemedicine, Traditional healthcare, Healthcare access, Health disparities, Health inequities, Diabetes Mellitus Type 2, Urban medically underserved populations, Marginalized communities, Social determinants of health.

EFFECTIVENESS OF TELEMEDICINE IN DIABETES MANAGEMENT:

A RETROSPECTIVE STUDY IN AN URBAN MEDICALLY UNDERSERVED

POPULATION AREA (UMUPA)

by

LISA ARIELLAH WARD

B.S., Cornell University, 1976

M.A., University of Alabama, Tuscaloosa, 2000

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DOCTOR OF PUBLIC HEALTH

JIANN-PING HSU COLLEGE OF PUBLIC HEALTH

EFFECTIVENESS OF TELEMEDICINE IN DIABETES MANAGEMENT**:** A RETROSPECTIVE STUDY IN AN URBAN MEDICALLY UNDERSERVED POPULATION AREA (UMUPA)

by

LISA ARIELLAH WARD

Major Professor:	Gulzar H. Shah
Committee:	Linda Kimsey
	Hani Samawi
	Jeffery A. Jones

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DEDICATION

I dedicate this work to my family, in particular, my 92-year-old mother, who has always been an encouragement to me despite her speech difficulties brought on by a stroke. My father, who is no longer with us, would have been immensely proud of my achievements. My beloved children, Chauniqua, Michaiah, Shawn (son-in-love), Jemuel, Lauren (daughter-in-love), and Johanan were constantly encouraging and supportive of me. To my grandchildren, Haamiah, Saoirse, Liam, Aoife, Tadhg, Ezra, and Calvin, I say: You were created for a purpose and destiny, anything is possible! Pursue your dreams with passion. Thank you for your beautiful artwork which are displayed on the walls in my office as a daily reminder of your love and support. As a child, my grandmother inspired me by earning her first degree at the age of 72.

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CHAPTER I
INTRODUCTION

The context of this study is based on health disparities and access to healthcare services utilizing telemedicine (TM) for managing diabetes among Urban Medically Underserved Populations (UMUPAs). The research project is the first to coin UMUPA as a neologism to describe the study population in a medically underserved area and associated access barriers to healthcare services. Populations living in medically underserved areas (MUAs) face significant personal and systemic barriers in obtaining adequate healthcare services. Barriers are problematic for people with chronic diseases in receiving the necessary, timely treatment in managing health, resulting in complications for disease management, and inadequate health outcomes. Management of type 2 diabetes mellitus (T2DM) has always been a top priority for public health (PH) and healthcare due to the pervasiveness of the disease.

This was a novel study examining the hemoglobin A1c (HbA1c) values of 111 patients with uncontrolled type 2 diabetes mellitus (T2DM) and 81 patients with prediabetes to determine the efficacy of employing TM technology as an alternative healthcare delivery service managing diabetes for people residing in UMUPAs. Retrospective electronic patient health records (PHR) dated January 1st, 2019 to June 30th, 2021 were examined from the UF Commonwealth Family Medicine clinic (CFMC).

The CFMC was designated as the" Technologically Mitigated Lower Socioeconomic (SES) Clinic," by Dr. Christopher Scuderi, UF's former Chief Medical Director. The CFMC is geographically located in an UMUPA in Duval County, Jacksonville Florida.[2,3] The Duval County population is representative of communities impacted by social determinants of health

(SDoH) with similar racial and ethnic characteristics, chronic illnesses, financial and transportation challenges creating barriers to healthcare services.

The Severe Acute Respiratory Syndrome Coronavirus 2 (SARS-CoV-2) is the virus that spawned the Coronavirus disease 2019 (COVID-19) which led to the global pandemic and perpetuated barriers for vulnerable populations. The first US confirmed laboratory case of COVID-19 reported to the Centers for Disease Control and Prevention (CDC) was on January 22nd, 2020, according to a 2019 Morbidity and Mortality Report (MMWR).[4] March 11th, 2020, was the official day the World Health Organization declared COVID-19 as a pandemic. COVID-19 became the deadliest disease in US history two years later, in March 2022, with a death toll approaching one-million people, surpassing all previous pandemics.[5,6]

Throughout the Coronavirus pandemic, the terms health inequity and disparity have become ubiquitous and suffused within our culture as they relate to disadvantaged populations. The terms health, health disparities, health inequity, and equity are used frequently throughout the discourse of this research. Health is described as a fundamental human right, which is attained when everyone reaches their full potential of health and wellbeing.[7,8] A health difference resulting from unfair or unequal exposure to harmful social and health conditions, is referred to as a health disparity.[9] Health disparities often arise as a result of social, economic or environmental disadvantages[9] among marginalized populations who experience worse health risks and outcomes, and lower quality of life (QoL) than more advantaged social groups.[7,10]

Health inequities are defined as systematic, uneven distribution of disparities throughout communities,[8] creating greater obstacles to accessing healthcare and negatively impacting a person's health.[9] The historical deprivation or exclusion of privileges and discriminatory treatment against specific marginalized groups, such as racial and ethnic minorities and low-income populations, are often the primary drivers of health inequities.[9]

Equity described as the “absence of unjust, avoidable, and remediable health disparities among socially, economically, demographically, or geographically defined population groups by the World Health Organization (WHO).[7,11–13]

Dr. Camara Jones, past President of American Public Health Association (APHA), succinctly defined institutionalized or structural racism as: "the constellation of structures, laws, practices, norms and values together that result in disproportionate access to the goods, services and opportunities of society by race."[13(p. 19)] Racism has been a well-known factor as a leading cause of health disparities[12,15] contributing to disease, poverty, lack of adequate resources, violence, and unfavorable neighborhood and living conditions.[9] Health disparities can be reversed if policies that influence systemic improvements in SDoH are developed.[7,16,17] Eliminating health inequities–disparities means developing and implementing realistic solution-based policies specifically addressing the underlying SDoH factors that created healthcare access barriers.[12,15]

In 1966, Dr. Martin Luther King, Jr also stated before his speech at the 2nd convention of the Medical Committee for Human Rights (MCHR) “of all forms of inequality, injustice in health is the most shocking and the most inhuman because it often results in physical death”[18].

Social advantage often refers to a person's position in a social classification, categorized by wealth, power, and/or status.[7] In general, people in the 1% highest economic status, have a life expectancy of more than ten years than those in the lowest 1% SES.[19] The economic disparity between the wealthiest and most impoverished groups widened in the early years of the 21st century,[19] which was compounded by the deleterious health effects of the pandemic.

Healthcare spending in the United States (US) is the highest in the world, reaching $3.8 trillion in 2019, accounting for nearly 18% of the country's gross domestic product (GDP).[20] Despite national increases in healthcare spending, racial and ethnic minorities in the US continue to suffer from a lack of healthcare access, leading to inadequate health and a declining quality of life (QoL).[12,15]

Considering that the US has the highest global healthcare expenditures, advanced medical technology, and pharmaceutical resources, the pandemic revealed one of the highest mortality rates and poorest health outcomes among industrialized countries at every life stage.[21(p287),19,22] The COVID-19 pandemic highlighted pre-existing access issues, resulting in disproportionately higher risks of infection, higher morbidity and mortality rates among minority, underserved populations.[23,24]

Confluence of Events

The literature highlights the virus's high mortality rates attributable to a person's pre-existing chronic diseases and co-morbidities.[24,25] The risk of complications and death from the SARS-CoV-2 virus has been reported as higher among people with pre-existing health conditions– heart disease, diabetes, and respiratory diseases.[26] However, it's asserted that a confluence of events related to structural and systemic inequities were the major contributors to the disproportionately high morbidity and mortality rates among minority groups.[6–9] Black and brown people tend to work in front-facing jobs, often using public transportation, encountering higher rates of exposure, leading to excessive vulnerability for contracting the virus.[13(p 54),23,26] Minority populations experienced higher rates of morbidity and mortality due to fewer safeguards, limited personal protective equipment (PPE), higher exposure rates, the propensity of having comorbidities related to chronic disease, and limited access to healthcare services.[13(p 54)]

Systemic conditions included a weakened infrastructure, a shrinking PH and healthcare workforce, decreased access to urgent and critical services, and an inadequate medical equipment, and supply chain shortages.[23,24,27,28,31] A 2016 systematic review (SR), reported that a shortage among primary care providers (PCPs) would occur by 2020.[29,30] The shortage of PCPs, contributed to a ripple effect, which exacerbated capacity issues and restricted effective disease management primarily among marginalized populations.[31]

PH’s role, challenges and COVID-19

The framework that defines PH’s role[32] of protecting and promoting the health of all people in all communities is the 10 Essential Public Health Services (EPHS).[32] Eliminating systemic and structural barriers that contribute to health disparities is a priority set forth by EPHS.[32] The EPHS, initially established in 1994, fell out of step with the current needs in PH practice,[32] created the urgency to revitalize the framework. PH was unable to provide the critical services required to mitigate the negative consequences of the COVID-19 pandemic.[32]

Some of the primary components impeding PH’s capability in accomplishing its mission and aims during the pandemic, according to the CEO of the de Beaumont Foundation, were obsolete data systems, unheeded PH policies, lack of essential partnerships, communication failures, a reduced PH workforce, and depleted resources.[32] In 2019, the de Beaumont Foundation and the Public Health National Center for Innovation conducted a nationwide survey of stakeholders to revise the outdated EPHS framework.[32] The 2020 primary survey results were released, which clarified PH's fundamental role, incorporated a major paradigm shift, and emphasized equity, which will optimize and improve health and QoL, particularly for historically marginalized groups.[32]

Another factor that exacerbated health challenges during the pandemic was a decline in the PH workforce, which stifled resources and hampered the advancement of PH policies that promote health equity in marginalized populations.[33] The 2020 Public Health Workforce Interests and Needs Survey (PH WINS), predicted a labor force shortage due to the resignation or retirement of 42% of PH personnel creating a silver tsunami.[33] The PH WINS survey, suggested that the potential loss of PH professional years of expertise is equivalent to "742,000 years."[34] PH professionals are trained to engage communities in a linguistically appropriate, culturally sensitive manner, which contributes to dispensing critical lifesaving information and services.[35,36]

The Paradigm Shift and TM

Events spawned by the COVID-19 pandemic initiated a paradigm shift for the healthcare and PH sectors, which propelled the urgency to find alternative healthcare access solutions and resulted in the expansion of TM services in primary care settings.[37] The shift required the implementation of new public safety measures to decrease the virus' spread. The newly mandated healthcare system safety protocol established by CDC and WHO guidelines were clinic occupancy restrictions, reducing patient/provider visit sessions, minimizing direct contact by social distancing, and increasing hygienic practices.[25,38,39,37]

According to an MMWR report, there was a 154% increase in telehealth visits during the last week of March 2020 compared to the same pre-pandemic time period in 2019.[40] Health centers in urban areas reportedly were more likely to provide greater than 30% of visits virtually compared to rural areas.[40] The U.S. Department of Health and Human Services (HHS), Assistant Secretary for Planning and Evaluation (ASPE) report found that Medicare visits conducted through telehealth increased 63-fold, from approximately 840,000 in 2019 to 52.7 million in

2020.[40] Due to COVID-19's high transmissibility, F2F visits were reduced, and TM technology was identified and implemented as a safer alternative into the healthcare matrix due to its ability to conduct remote, online consultations between primary care providers (PCPs) and patients.[37,29] TM was pivotal in facilitating the deployment of CDC's and WHO's emergency safety protocols reducing morbidity and mortality rates [41] becoming the frontline defense against the spread of disease.[38]

Statement of the Problem

One of the greatest challenges in PH and healthcare is implementing policies to increase healthcare access and reducing inequality gaps among vulnerable communities. Healthcare service access barriers prevent persons with chronic diseases from receiving the essential, timely treatment for managing their health, resulting in disease management complications and adverse health outcomes. Since impediments to healthcare access and health inequities pose a significant threat to the livelihood and wellbeing of vulnerable populations, the US healthcare system and PH are coming under increasing demands to find solutions for improving population health.[37]

Even though barriers to healthcare access among racial and ethnic populations are well documented in the literature,[8,13,42] there is limited evidence of successful interventions that provide feasible solutions for people in UMUPAs.

In this study, the term "access" refers to the type of healthcare service (TM or F2F) and the appropriateness or fit [43] for people living in UMUPAs. Our current healthcare system is primarily structured as a F2F mode of care, requiring patients to come in to a healthcare provider's office or clinic to manage healthcare needs.[43,44] The F2F approach creates systemic barriers for people in disadvantaged groups from receiving the essential, timely healthcare services required to offset medical complications to manage health.

As a society the emphasis on healthcare has been a pathogenic approach to disease management placing emphasis on tertiary care as the primary course of therapy for diagnosing and treating chronic conditions. The pathogenic approach or tertiary care refers to treating a chronic illness after the disease has developed and progressed, rather than addressing underlying systemic factors known as primordial prevention.[23(chapt2,p.179-182] The tertiary course of disease management is the most expensive and ineffective approach to healthcare.[43(p6,43)] The CDC reports that the cost of treatment for chronic disease is estimated to account for more than 75% of the national healthcare expenditures.[45]

The aim of this research is to provide an alternative approach to traditional healthcare and a potentially cost-effective approach to improve disease management and healthcare access for marginalized populations. The Veteran's Health Administration's (VHA's)–21st century digital framework serves as the underpinning for this study. The VHA framework describes a technological adaptation of the Penchansky and Thomas' 20th century theory postulating five dimensions for improving healthcare access. [46,47] The term access identified by Penchansky and Thomas' 5A's and the VHA are dimensions of fit including: accessibility (geographical), availability (temporal), acceptability (cultural), affordability (financial), and accommodation (digital).[48]

Purpose of the Study

The purpose of the study is to determine if there is an association between TM appointments and traditional in-person visits and the clinical outcome of patients with diabetes and hemoglobin A1c (HbA1c) values. Managing HbA1c values and achieving optimal glycemic control is critical for persons with diabetes in mitigating long-term micro and macrovascular complications that results from poor diabetes management.[49]

The study examines retrospective electronic PHR from patients with uncontrolled diabetes and prediabetes who used TM or F2F encounters for managing diabetes by analyzing HbA1c values as glycemic control.[50] The study evaluated patients at the extreme ends of the diabetes spectrum, from the earliest development of diabetes (prediabetes) to the latent (uncontrolled diabetes) stage, to discover if employing TM or F2F for healthcare visits results in HbA1c % value changes.

Patients with prediabetes and uncontrolled diabetes are at a critical juncture in terms of clinical outcomes and it is essential to provide timely intervention to halt the progression of elevated HbA1c values, from uncontrolled glycemic levels which are linked to complications. Therefore, increasing timely access to care contributes to early intervention strategies, lowering the potential for developing negative health consequences.

While TM technology has shown improvement in disease management,[51] more studies are needed to evaluate the long-term viability of healthcare access for populations residing in UMUPAs.[52–54]

Research Questions

The study was guided by the following research questions and hypotheses.

Research question 1

RQ1:

Is there an association between the ratio of healthcare service visits via TM-to-traditional mode of care and the difference in mean HbA1c values for TM-to-traditional office visits in T2DM patients with uncontrolled diabetes (=>8.0%), during the study period from January 1st, 2019 to June 30th, 2021?

RQ1 Hypotheses

H_{01}: There is NO association between the ratio of TM-to-traditional office visits and the difference in mean HbA1c values for TM-to-traditional office visits in T2DM patients with uncontrolled diabetes (=>8.0%).

H_{A1}: There is a significant association between the ratio of TM-to-traditional office visits and the difference in mean HbA1c values for TM-to-traditional office visits in T2DM patients with uncontrolled diabetes (=>8.0%).

Research question 2

RQ2:

Is there an association between the ratio of healthcare service visits via TM-to-traditional mode of care and the difference in mean HbA1c values for TM-to-traditional office visits in patients with prediabetes (=>5.7% – 6.8%), during the study period from January 1st, 2019 to June 30th, 2021?

RQ2 Hypotheses :

H_{01}: There is NO association between the ratio of TM-to-traditional office visits and the difference in mean HbA1c values for TM-to-traditional care visits in patients with prediabetes (>=5.7–6.8%).

H_{A1}: There is a significant association between the ratio of TM-to-traditional office visits and the difference in mean HbA1c values for TM vs traditional office visits in patients with prediabetes (>=5.7%–6.8%).

Delimitations

The UF institutional review board (IRB) recommended an approved 3rd party, integrated data repository (IDR) to collect data. The IDR analyst was responsible for data collection, deidentification, and recoding of all patient's medical records, including the dates of service, service type codes, and medical record numbers (MRNs). This researcher worked in close collaboration with the IDR analyst to clarify and resolve any ambiguous data conflicts to insure accuracy of data collection.

The first research question will evaluate if there is an association between the ratio of TM/F2F and the difference in the mean HbA1c values comparing the mean HbA1c values in TM to the mean HbA1c values in F2F in T2DM patients with uncontrolled diabetes (=>8.0%).

The second research question will evaluate if there is an association between the ratio of TM/F2F and the difference in the mean HbA1c values comparing the mean HbA1c values in TM to the mean HbA1c values in F2F in patients with prediabetes (=>5.7%-6.8%).

Significance of the Study

COVID-19 aided the catapulting of TM technology, initiating a paradigm shift in the US healthcare delivery service industry.[38,55] TM is becoming an essential, life-saving tool that reduces access barriers by providing healthcare services for people that would otherwise lack timely, adequate medical care. The research is relevant for people living in MUAs with chronic disease where health disparities are prevalent and access to healthcare is inadequate.[56] Expanding TM technology to these communities may reduce the health burden and considerably enhance QoL.

Definition of Terms

Disability:

Any physical or mental disability (impairment) that makes it more difficult to perform specific tasks (activity limitation).

Disease burden:

Designates the incidence and prevalence of the disease within the population.

Glycated Hemoglobin A1c (HbA1c):

Red blood cells (RBCs) transport oxygen from the lungs to all of the body's cells. As glucose enters RBCs, it bonds (or glycates) with hemoglobin molecules. Hemoglobin glycation is proportional to the amount of glucose in the blood. Calculating the HbA1c percentage in the blood provides an overview of a persons' health status related to diabetes.

Healthcare access:

Access is the ability or ease with which individuals or communities may use appropriate services according to their needs, whether that access is to a service, a provider, or an institution.

Health Disparity:

Refers to persons who are socially disadvantaged and have the poorest health. Disparities are imbalances in the differences in the levels of treatment and services allocated to distinct populations based on economic, social, or environmental circumstances.

Health Equity:

Health equity is defined by WHO as the absence of disproportionate, avoidable, and remediable differences in health among socially, economically, demographically, or geographically defined population groups.[16]

Health Inequities:

Health inequities are described as socially induced health disparities that are systematic and dispersed repeatedly across communities.

Medically Underserved Population Area (MUPA):

Medically underserved areas (MUAs) and medically underserved populations (MUPs) are communities in specific geographical locations where there is a shortage of physicians and primary healthcare facilities. Populations in MUPAs may experience limited modes of transportation, being unhoused, socio-economic deficiencies, cultural and literacy barriers limiting their access to healthcare services. Urban Medically Underserved Population Areas (UMUPA) refer to the study's population residing in the metropolitan area of Jacksonville, Florida.

Population Health:

Is characterized as a grouping of a populations' health outcomes, that can be quantified in terms of (mortality, morbidity, health, and functional status).[57]

Social Determinants of Health (SDoH):

The term SDoH is described by the WHO as "preventable conditions that are principally responsible for unjust health disparities and inequalities."[58] The SDoH are the conditions in which people learn, grow, live, worship, work, play, and age.[59] There are multilevel underlying conditions which form the SDoH framework and impact the QoL and health outcomes–[discrimination, lack of employment opportunities, education level, marital status, overcrowded housing conditions, lack of green spaces (built environment), transportation systems, SES, access to health services, and lack of health insurance].

Tele-health:

Is the technology-based virtual platforms used to support distance-based clinical communication between providers and specialties; professional health-related education and training; sharing surveillance data with PH, storing and forwarding health data and information; and prevention and monitoring.

Telemedicine:

Is the largest segment of telehealth described as the practice of medicine via remote, audio/video technology allowing providers and patients synchronous or asynchronous communications without time, distance, or other constraints. It is an online physician evaluation and management tool for clinical decision-making utilizing electronic communication as a substitute for in-person meetings.

Underserved populations:

Populations that share one or more of the characteristics are considered underserved, if they: receive less healthcare services due to encountering multiple barriers(e.g., financial, cultural, and/or linguistic), are unfamiliar with the process of healthcare system delivery; live in areas that have a scarcity of healthcare facilities and/or providers.[60]

Vulnerable populations:

Populations described as vulnerable are those who have one or more of the following characteristics: a high risk for health problems and/or pre-existing conditions, have limited life options (e.g., financial, educational, housing), lack access to transportation services, have fear and distrust in accessing government programs or disclosing sensitive family information, have physical or intellectual disabilities–limited English proficiency [LEP] or cognitive, hearing, speech and/or vision impairments reducing their ability to communicate, have mobility impairments, and experience any form of discrimination.[60]

CHAPTER II

LITERATURE REVIEW

The purpose of this literature review is to explore the role of TM for diabetes management in the clinical healthcare setting and its impact for employing it as an option for healthcare delivery service in UMUPAs. This research will analyze synchronous TM–audio or videoconferencing communication between the CFMC healthcare practitioners and patients.

The conceptual framework that establishes the context for this research is based on the VHA 21st century digital framework for healthcare.[61] TM has attracted considerable prominence for patient healthcare delivery as a result of the COVID-19 pandemic.[54] COVID-19 was the catalyst initiating a paradigm shift in the healthcare and PH sectors, propelling an urgency for finding healthcare access alternatives, resulting in the expansion of TM technology in primary care settings. This propulsion which increased TM utilization launched an unprecedented opportunity for geographically marginalized populations to receive timely, high-quality healthcare in their local setting.[52] TM offers the long-term, viable and practical option for healthcare delivery services for people living in marginalized areas.[62]

Telehealth, TM, telemonitoring, remote monitoring, mobile (mhealth) and electronic health (ehealth), telemetric interventions, and virtual encounters are common terminologies used for describing electronic technologies facilitating communication between patients and providers, separated by geographical location.[63] Telehealth and TM are the most common types of distance-based technology and the terms are frequently used interchangeably for sharing medical information and delivering healthcare when providers and patients are unable to meet in-person.[64]

The American Telemedicine Association (ATA) makes a distinction between TM and telehealth. TM is typically associated with direct remote patient "clinical" services, whereas telehealth encompasses a broader scope of health-related services including education and remote monitoring.[43,65] There are three types of TM encounters: provider to patient, provider to provider, and patient to ancillary services including (health coaching, technicians, and web-based interactive modules.[64,66,67] The three types are classified as synchronous, asynchronous and continuous remote patient monitoring (RPM).[51] Synchronous communication is live, real-time, and direct (audio-based – mobile or landline phones, or video-internet-based).[41] Asynchronous communication, also known as store and forward (SF) communication, is defined as previously uploaded medical data (examples are glucometer readings, diagnostic/radiological tests, medical records, and clinical documentation) used for future transmittal.[51]

Continuous RPM telemonitoring is the combination of telehealth and technical biometric devices (digital glucose, blood pressure, and heart monitors) providing real-time data to medical providers, allowing close monitoring of patients with chronic conditions, potentially avoiding emergencies. Bioanalytics (wearable technology that tracks fitness, physical activity, step counters, and sleep patterns) is another component of continuous monitoring.[68]

The research questions will explore the scalability and feasibility of TM for generalizable application among marginalized populations with limited healthcare resources and access. More evidence-based research is needed to determine if TM has lasting benefits related to chronic disease and specifically diabetes management and improved glycemic control. This research will focus on TM as an alternative healthcare delivery service addressing health disparities in UMUPAs related to managing diabetes.

The limited number of US based research articles demonstrates the need for more studies on this crucial topic. Despite the global expansion of TM utilization, few studies have been conducted to demonstrate its effectiveness in diabetes management with the potential for healthcare access improvement among marginalized populations.[42] Hence, this study is particularly relevant in contributing to the research to assess the effectiveness of interactive, synchronous TM as an alternative resource for healthcare delivery and patient care for marginalized populations.

Prior to the pandemic, the most frequently used type of healthcare service was F2F visits, requiring in-person attendance in a medical office for treatment. Populations living in MUPA/UMUPAs face significant barriers in obtaining adequate healthcare services due to insufficient transportation, limited financial resources, lack of healthcare providers or facilities, or physical or mental health challenges.[43] In addition, people living in MUPA/UMUPA's experience various systemic and personal barriers for acquiring healthcare services, including difficulties attracting and retaining healthcare providers in the local communities, provider caseloads and backlogs, and lacking resources to maintain existing facilities.[43]

Literature Search Specifications

This research explored US-based, and International English language publications, free full text, peer-reviewed journals in the following electronic databases; Google Scholar, PubMed, Medline (Ovid), Embase, EBSCO host, National Library of Medicine (NLM), PubMed, PubMed Central, ProQuest Dissertations and Theses, Telemedicine Information Exchange, Cochrane Database of SRs, and Science Direct [Elsevier], from January 2000 to March, 2022. Zotero was used as the reference management software for all research materials.

The inclusion search criteria for this research were: TM, telehealth, remote monitoring, type 2 diabetes mellitus (T2DM), healthcare access barriers, COVID-19, social determinants of health, and health inequities–disparities. The exclusion criteria were all other ancillary telehealth specializations such as; (tele-dentistry, tele-pharmacology, tele-ophthalmology, tele-radiology, tele-psychiatry, tele-dermatology, tele-pathology), gestational, and type 1 diabetes. Major themes of the study were organized into three major categories: TM, SDoH and T2DM.

Telemedicine Overview

Despite the fact that interest in TM has grown in recent years as a result of recent improvements in telecommunication technology and COVID-19, it is not new.[69] TM has grown from modest beginnings, now recognized by the Journal of American Medical Informatics for health and medical informatics as an essential core curriculum focusing on expanding and training medical professionals in utilizing TM applications in the healthcare environment.[69] The training goal is to support the expansion of telecommunication technologies to improve distance-based healthcare delivery.[69]

The COVID-19 pandemic resulted in significant morbidity and mortality rates, overburdening the US healthcare system and limiting patients' access to traditional healthcare.[70,71] As a result of the pandemic, TM technology was propelled into the forefront as an alternative healthcare delivery service. [72,73] Therefore, TM was identified as a critical driver and tool for change in the 21st century healthcare delivery system halting the spread of the virulent COVID-19 disease.[72,73] TM technology has also been shown beneficial for marginalized populations,[54,71,74] where geographical, systemic, and personal barriers had formerly hampered access to care.[65] The TM technology shattered the glass ceiling as a sine qua non for healthcare delivery services in the US.[61]

The questions remain–is TM a viable alternative to F2F healthcare for patients with chronic diseases to help them achieve or maintain positive health outcomes? Will TM be scalable to implement future PH initiatives to address healthcare access barriers and the digital divide?

Telemedicine–Past

The first clinical application of TM, was in cardiology beginning in the 1920s through the 1940s.[75] Medical facilities in France, Italy, and Norway conducted radio consultations to healthcare providers for patients who were on ships and remote islands.[75] The US began the first wave of organized TM technology in the 1950s using telognosis for transmitting original radiographic facsimiles (faxes) called roentgenographic by radio or telephone over short distances.[76]

In 1996, the Institute of Medicine (IOM) now known as National Academy of Medicine (NAM) released its report, "Telemedicine: a guide to assessing telecommunications for healthcare."[77] The Telecommunications Act of 1996 implemented by the Federal Communications Commission (FCC) supported the expansion of the technology.[78] The lack of institutional long-term funding, licensing requirements, insurance reimbursement, broadband limitations, planning and design challenges, privacy and confidentiality concerns, and the legal, ethical, and regulatory environments all prevented the widespread adoption of TM.[69,78]

The Health Information Technology for Economic and Clinical Health (HITECH) Act of 2009 established the framework for interoperable technology supporting data sharing among stakeholders. One of the early adopters of health information technology exchange (HIT), was PH envisioning it as a game-changing tool for improving real-time communication transmitting data between stakeholders.[16(p 12)] However, the adoption of TM technology encountered resistance in healthcare settings despite the available infrastructure and initiatives to support its expansion.[43]

Since its early adoption, TM has drawn increasing attention in both the private and public sectors. The numerous barriers that limited the expansion of TM prompted NAM to explore ways to augment and integrate TM into the healthcare environment.[77] The Health Resources and Services Administration (HRSA) hosted the IOM workshop with the goal of creating strategies to investigate the expansion of high-quality healthcare services to rural populations, to identify information gaps and synthesize the available evidence-based data, and to discuss HHS' role regarding the expansion of telehealth services with the goal of improving healthcare outcomes while improving operational efficiency.[77]

The Affordable Care Act (ACA) of 2014 also promoted TM as a team-based, patient-centered approach for reducing health inequities–disparities.[43] A significant contribution was made by ACA for reducing health disparities by removing system-level (geographical and financial) barriers and expanding healthcare access in rural and regional areas.[78-80]

Telemedicine–Present

According to a 2019 poll conducted prior to the COVID-19 pandemic, TM was underutilized with only 8% of Americans using the technology.[79] There were several challenges and roadblocks that initially hampered practitioner's adoption of TM in the clinical setting. Medical practitioners exhibited strong preferences for F2F practices, were hesitant to transition from paper to digital documentation, and constrained by insurance companies' strict reimbursement policies for TM sessions.[80]

COVID-19 has been a major factor driving online business, remote work, and social activities, requiring most people to change their lifestyles to accommodate technology.[81] The current lifestyle adaptation to technology was instrumental in bolstering providers' and patients' confidence in TM as a beneficial and effective online tool. The digital age of telecommunications and interoperable applications is gaining momentum and constantly expanding.[82] The application of telecommunications technology in healthcare is becoming a routine standard of care in many urban and rural areas throughout the country.

UF Health Jacksonville and TM

UF Health located in Duval County, Jacksonville Florida launched their first TM program in 2014, employing the EPIC software as its EHR. Patients have continuous access to PHR managing healthcare through the UF Health MyChart, an online patient portal. MyChart provides secure electronic messaging to healthcare providers, test results, request prescription refills, and schedule appointments.

Duval County's overall population is approximately 1,280,000 people (61% White, 29% Black, and 10% other races and ethnicities.[2,83,84] Duval County is a unique county comprised of three distinct geographical regions–urban, suburban, rural, and six HealthZones (HZs). The six HZs in Jacksonville, Florida are HZ1–Urban Core, HZ2–Greater Arlington, HZ3–Southeast (SE), HZ4–Southwest (SW), HZ5–Outer Rim (Rural), and HZ6–Beaches. HZ1 is the most densely populated area in Duval County of over 100,000 residents,[55,77] with minorities making up the highest percentage (83%) of the population.[2,83,84] HZ4 has the next highest minority population.

The Duval County Health Department (DCHD) uses HZs to track health initiatives by HZs which is delineated by unique economic and demographic disparities.[85] HZs are distinguished by zip codes and have index values that range from 0 to 100.[86] The higher index values indicate the greatest socioeconomic need based on income, unemployment, occupation, educational attainment, and linguistic barriers.[87] The higher index values are also linked to poorer health outcomes, including preventable hospitalizations and premature death.[87]

In 2016 the US Census Bureau reported that residents living in the zip codes HZ1–(32202, 32206, 32208, 32209, 32254), HZ2–(32211), HZ4–(32212), 32227, HZ5–(32234) have the highest socioeconomic need of all zip codes within the Northeast Florida, in the UF healthcare service area.[86] People under the age of 65, living in HZ1 have the highest rate of chronic disease, particularly diabetes, as well as the highest rate of emergency room visits for diabetes-related hospitalizations in Florida.[84,88]

Commonwealth Family Medicine Clinic (CFMC) and TM

The CFMC is one of the UF Community Health Medicine Clinics (CHMCs) and is located in an UMUPA in Duval County, Jacksonville Florida.[2,3] The majority of the CFMC's population reside in Duval County, Jacksonville Florida in HZ1. Duval County's population is representative of communities impacted by SDoH with similar racial and ethnic characteristics, chronic illnesses, geographical, financial, and transportation challenges that create barriers to healthcare services.

Among the CHMC's, the CFMC has the highest number of patients enrolled in the patient's electronic health portal, throughout the entire UF Jacksonville Healthcare system, and was designated as the UF Technology Mitigated Lower SES Clinic by Dr. Christopher Scuderi, the former Chief Medical Officer. Currently, 95% of CFMC patients are active users of the Epic MyChart patient portal, which houses the TM technology in the EHR system. Dr. Scuderi, asserts that the CFMC's high patient portal enrollment rate utilizing TM technology for their healthcare needs dispels the misconception that people from lower SES backgrounds with less education have difficulty using technology.

Patients receive individualized coaching from CFMC's medical assistants during every visit for those who are not currently utilizing the patient portal. The inclusion of TM training with personalized instructions has helped patients overcome barriers in using technology.

Provider perspective–TM

The pandemic was influential in altering healthcare providers' perception of TM, now recognized as a beneficial tool, providing disease transmission reduction and quality patient care.[70,89,90] The interoperability and efficiency of TM technology enhances providers' decision-making capabilities, by having convenient access to patients' comprehensive medical records.[91,62,71,78] Healthcare providers also use TM for monitoring, early identification and prioritization of care for patients with elevated health risk markers.[89,90,92] Direct access, allows providers to evaluate, triage, and treat patients for emergent conditions before a medical crisis occurs, averting unnecessary emergency room visits and hospitalizations.[93] Research shows that synchronous audio/videoconferencing between provider and patient, enhances patient satisfaction [94–96] and results in greater adherence to prescribed therapy.

Patient perspective–TM

Patients describe the advantages of TM as time saving, prompt assistance, scheduling convenience, availability of personal medical records, and 24-hour access to healthcare services from any location.[95] The ease of TM reduces system and personal level barriers that would otherwise delay patients from receiving timely healthcare service. TM saves money, helps working people avoid lost work time, costs related to child and family care, and enables accessibility to people who have transportation, mobility, physical or mental health limitations who reside in geographically challenged areas–MUPA/UMUPAs.[48,94]

Virtual diagnoses and treatments are beneficial for healthcare providers and patients by minimizing financial, geographical, temporal, and accessibility limitations. Data suggests that improved preventative treatment will minimize complications, reduce downstream costs, and hospitalizations associated with poorly controlled diabetes.[94-98]

Glycemic Control and TM

Having optimal glycemic control is critical for persons with diabetes. Long-term micro and macrovascular complications often result from poor diabetes management and uncontrolled HbA1c values.[49] The benefits of TM for managing T2DM and reducing HbA1c levels have been reported in recent literature.[54,55,73,99]

Reducing mean HbA1c values in patients with T2DM is associated with mitigating the risk of diabetes-related death and microvascular complications in patients with T2DM. The UK prospective diabetes (UKPDS) conducted an observational study of 23 hospital clinics in three countries (England, Scotland, and Northern Ireland), showed that a 1% reduction in mean HbA1c is associated with a 21% reduction in mortality related to diabetes and a 37% reduction in microvascular complications in patients with T2DM.[100]

The Journal of Medical Internet Research, in 2021, conducted a 12-year (2008–2020) comprehensive systematic literature search on the effectiveness of TM interventions for managing T2DM. The interventions included; (synchronous–audio/video, asynchronous–email, text messaging, internet/web-based communication, for managing glycemic control.[101] The comprehensive search was consisted of 99 studies–73 randomized control trials (RCTs), 9 qualitative studies, 2 cohort studies, 2 non-RCTs, 2 observational studies, and 1 noncontrolled intervention study.[101] The studies included 82,000 cases from 16,000 patients from 7 countries with the results reporting the mean HbA1c decrease of -1.15% with an average HbA1c value of 6.95%.[101] The final results revealed significant improvement in T2DM management utilizing TM interventions compared to F2F visits.[101]

The World Journal of Diabetes conducted a review in 2021 of 43 meta-analyses (MAs) synthesizing RCTs dated over 31 years (1989-2020), reporting a significant overall reduction of .49% difference in mean HbA1c values.[102]

A long-term RCT of TM case management was undertaken by the Informatics for Diabetes Education and Telemedicine (IDEATel), found that patients maintained improvement in HbA1c values of 0.29%, for over a 5-year period.[93] The IDEATel study population were adults over 55 years, ethnically diverse (African-American and Hispanic), fluent in English or Spanish, Medicare beneficiaries with T2DM, residing in federally designated MUAs or Health Professional Shortage Areas (HPSA) of New York State.[93]

The body of evidence for TM's usefulness has been expanding, notably in terms of glycemic management assessed by HbA1c values.[103,104] Patients of varying demographics achieved similar clinical benefits.[105] Newer evidence suggests that healthcare practitioners employing virtual technology compared to F2F visits for patient care achieved similar positive health outcomes, related to improved diabetes management and reduced HbA1c values.[53,85,106,107]

Overall, many studies indicate promise for the clinical benefits of TM to improve healthcare delivery access to underserved populations with diabetes,[74,90,108,109] and may be the compelling factor advocating for expansion of broadband connectivity in geographically isolated areas.

Digital divide

The digital divide is a long-standing, complex, and difficult PH issue that posits technology as disadvantageous for marginalized populations. The phrase "digital divide" was adopted in the latter part of the 20th century referring to the vast schism between those who had access to technology and those who did not.[110] According to studies, marginalized communities in geographically isolated locations with unequal access to technology,[109,110] were considered as disadvantaged groups based on SES, education, race, ethnicity, gender, and age, which leads to health disparities.[111] Current assertions of a digital divide stem from widespread infrastructural limitations in communities with inadequate broadband connectivity, and associated expenditures to obtain and maintain internet service.[110,113,114]

According to a recent 2018 Stats Brief, to the US Department of Education, adults who are not digitally literate have challenges accessing and utilizing technology,[115–117] are more likely to be less educated, have lower SES,[118] older, Black, Hispanic, or born abroad, and tend to work in lower skilled jobs.[119]

The survey reports that White adults accounted for over half (46%) of adults who are not digitally literate and the overall estimate for Americans who lack computer or technological competency, is approximately 16% (31.8 million).[119] When compared to White individuals (11%) there are twice as many Black adults who lack digital literacy.[119] Minorities have a disproportionately higher percentage of persons who lack digital literacy relative to the entire population of White adults. The digital divide argues that technology will widen the disparity gap and worsen health outcomes among rural populations.[120–122] Studies that focus on obstacles encountered by rural communities, omit the complex systemic challenges faced by urban dwellers who reside in UMUPAs.

While arguments regarding a lack of internet access due to broadband limitations and technological device ownership were relevant in the early part of the 21st century, a 2020 Pew Research Center (PRC) poll discovered that households no longer lacked technology or found it difficult to use.[81] The PRC polled over 4000 households across all US demographics (racial, ethnic, SES, gender, and age) reporting nine out of ten people viewed the internet favorably. Three-quarters (78%) of the polled respondents saw the internet as a huge benefit to society with the advantages outweighing the disadvantages.[111]

A 2021 PRC survey reports the gap between younger and older internet users narrowed in the last decade, with older adults 65 and over now regarded as major technology adopters.[123] The survey also reports that low-income young adults with a high school diploma are more reliant on their mobile phones than PC's or laptop computers for internet access.[111] Recent survey results dispute the former arguments related to literacy, age, race or educational skill level in using technology and the digital divide.

The public's perception of internet usage is shifting, and more research is emerging to support the accessibility, viability and efficacy of technology expanding to virtual healthcare delivery.[96] According to the 2021 PRC report, 72% (7 out of 10) rural households have access to broadband connectivity, but are less likely to own or use technological equipment due to lifestyle preference.[124]

The adoption of technology has helped broaden access to marginalized populations, but PH must continue to advocate for; broadband expansion to remote areas, affordable internet providers, and educate marginalized populations about the benefits of using technology for their healthcare services.

CMS Supporting TM

In 2019, Medicare and Medicaid, the two major US government-financed health insurance programs, covered the healthcare requirements for more than 140 million people, with expenditures of more than 3.8 trillion dollars.[125,126] Medicaid was the primary insurer for the healthcare needs of approximately 77 million low-income people, with total estimated costs over $673 billion (federal and state).[127] Due to the growing healthcare needs and expenditures, CMS sought alternative resources to meet the healthcare challenges of Americans.

In March 2020, CMS expanded support of TM technology by waiving many financial, administrative, licensure, and practice restrictions to address the massive healthcare expenditures, and rising mortality and morbidity rates incurred by COVID-19.[125] The new CMS policy waivers, made provision for all healthcare professionals (nurse practitioners, social workers, physician assistants, therapists) to receive compensation for the treatment of patients through TM.[125,127]

In 2020, Health Insurance Portability and Accountability Act (HIPAA) regulations[125] were modified during the pandemic, allowing virtual communication platforms (Doximity, Skype, Zoom) to securely exchange private medical information between patient and healthcare provider.[128] The CMS' revisions, modified policies, and regulations, currently offer people living in MUPA/UMUPAs an alternate source for healthcare services.

Public Health Leadership Implications

Building Bridges – PH and Healthcare

This research supports NAM and the Office of Disease Prevention and Health Promotion (ODPHP) objectives recognizing the importance of telehealth service expansion for improving healthcare standards for underserved populations. The bedrock for this research in PH leadership supports key population health policies accentuating TM in providing opportunities for cross-sectoral collaboration. Healthcare systems, PH, governmental entities, business and community stakeholders can collaborate to develop objectives and resource-sharing strategies with the goal of enhancing healthcare delivery in underserved populations.

The seminal report "*Crossing the Quality Chasm*: A New Health System for the 21st Century (2001)" published by the IOM/NAM, advocated for the integration of telehealth–TM into traditional healthcare settings to improve patient care. According to the NAM report, in order to achieve significant improvements in quality care, the healthcare system must be redesigned with a focus on population health and the incorporation of technology.[77,127(p 58)] The recommendation marked a significant milestone in the healthcare system, which historically focused on individuals' health, in contrast to a prevention-based, population-health approach.[19(p 5),127(p 40)]

NAM: The first objective of this research is to address NAM's recommendations for the healthcare system to reform their practice to a more technologically advanced, convenient, safer patient care system. NAM's recommendations align with PH's policy goals to reduce health disparities and improve population health. The recommended healthcare delivery system included a 21st century digital format, for continuous access to healthcare services that was available to patients–24 hours a day, 7 days a week, 365 days a year.[129(pp66-68)] Beginning in the early part of the 20th century, NAM used forward-thinking strategies supporting TM technology for improving patient access to healthcare.

ODPHP: The second objective of this study addresses two high priority Healthy People 2030 (HP2030) leading health indicator (LHI) goals.[130] One of the priorities includes expansion of telehealth/TM services [131] in MUPAs, and the improvement of health communication between patients and providers.[132,130] The second goal prioritizes risk reduction strategies to decrease the prevalence of diabetes and improve population health and QoL.[132] The LHI goals are still in the research phase and lack adequate evidence-based data; however, they are designated as important high-priority objectives for HP2030 to drive action for the improvement of national PH policies.[130] The research supports LHI goals by analyzing the effectiveness of utilizing TM technology as an alternative healthcare service for improving the medical necessities of marginalized populations. The study intends to supply more data contributing to the knowledge base of the LHI objectives.

Medically Underserved Areas (MUAs)

The CDC defines MUAs as populations residing in medically underserved areas where SDoH factors create substantial health challenges limiting access to healthcare services.[16,45] Underserved and vulnerable groups have distinctive attributes according to HHS.[57] *Underserved* populations commonly share one or more characteristics if they: receive fewer healthcare services, encounter multiple barriers (e.g., financial, cultural, and/or linguistic) in accessing and receiving basic healthcare services; are unfamiliar with the process of healthcare system delivery; live in areas that have a scarcity of healthcare facilities and/or providers.[57] *Vulnerable* populations generally include: a high risk for health problems and/or pre-existing conditions; limited livelihood options (e.g., financial, educational, housing); lack access to transportation services; have fear and distrust in accessing government programs or disclosing sensitive family information; have physical (mobility impairments) or intellectual disabilities; have limited English proficiency [LEP]; cognitive, hearing, speech and/or vision impairments that reduces their ability to communicate; and experience any form of discrimination.[57]

The study’s population are both vulnerable and underserved. These factors influence and often complicate people's ability to manage diabetes and other chronic diseases effectively. A 2020 MMWR indicated that counties with greater SDoH inequities were more likely to become COVID-19 hotspots and have higher rates of disease. Hotspot communities were reported highest among racial and ethnic minority populations.[133] Reports revealed significant geographical patterns in diabetes prevalence in select counties across the US were associated with greater rates of poverty, unemployment, and diabetes prevalence. The counties with higher diabetes prevalence rates were found in the southeastern region of the US known as the “diabetes belt.[134]”

Chronic disease/diabetes

In the US, diabetes affects over 38 million people, (approximately 10.5 % of the population[25,45] which includes 29 million who are diagnosed and 9 million undiagnosed.[135] Prediabetes affects approximately 96 million Americans, or one-third of the population, and more than 80% are unaware of it.[135] People with prediabetes are at risk for stroke, heart disease and T2DM.[136] Diabetes is the seventh leading cause of death in the US,[137] with cardiovascular disease being the primary contributor.[135] WHO reported that the global mortality rate from diabetes has risen to the top 10 causes of death, this represents a 70% increase since 2000 and an 80% increase in male death rates.[58,138]

Medical expenditures in 2017 for diagnosed diabetes was estimated to be $327 billion from direct and indirect costs.[139] Indirect costs are attributed to declining productivity at work and home, high rates of absenteeism, unemployment due to chronic disability, workers compensation, and premature morbidity.[135]

The MMWR reported in February 2021 to the CDC,[28,140] that 97 % of the COVID-related death certificates of 357,000 people had at least one other diagnosis, indicating that this was a significant contributor to the death rate.[141] The COVID-19 mortality rates showed a link to one or more disorders – hypertension, diabetes, or other chronic diseases – as well as a co-occurring chain of events – pneumonia or respiratory failure, or both.[25,142,143] Diabetes was identified as one of the five most common comorbidities associated with COVID-19.[144]

Diabetes and health disparities

Racial and ethnic groups have a disproportionate prevalence of diabetes, with higher rates of complications.[28,42,145,146] CDC identified the effects of historical systemic and structural disparities as key risk factors contributing to premature death among young minorities.[147] The prevalence of diabetes among blacks quadrupled in the past 30 years.[28,45,148,149]

COVID-19 had the largest impact on non-Hispanic blacks and Hispanics in April 2020, case rates (8.2 per 1000), people of Hispanic origin (9.7 per 1000) compared to non-Hispanic Whites (5 per 1000)[150] with Blacks having a 27% higher mortality rate.[138,144,146,151] The pandemic also highlighted a major research gap related to the negative impact of healthcare access barriers and racial/ethnic minorities in urban areas during a national crisis. Understanding the potential magnitude of a crisis could have averted the extensive morbidity and mortality rates among black and brown populations.[147]

Factors influencing HbA1c control

Hemoglobin A1c (HbA1c) known as glycated hemoglobin (Hb), is the most important indicator of glycemic control used by PCPs to diagnose and set treatment plans to manage diabetes.[152] Glucose glycates (sticks) to Hb when it is present in the blood.[153] Insulin is a pancreatic hormone that acts as a key allowing glucose into cells for energy. The pancreas attempts to stimulate cell response to remove the excess glucose, by producing more insulin, however, the pancreas stops producing insulin once it is overworked causing a buildup of glucose. When blood glucose increases it creates the potential for prediabetes, and if left untreated results in T2DM.[136]

The mean HbA1c % value is measured by a routine clinical test taken every two to three months to determine the level of glucose control in individuals with prediabetes or diabetes.[154] The A1c test gives the PCP precise information on the average quantity of glucose that was attached to the Hb over a longer time period in comparison to home monitoring devices that measures daily blood sugar.[153]

The ADA sets target medical care standards for people with diabetes called ABCs. The benchmark standards for ideal diabetes maintenance are as follows: (A) for A1c range (HbA1c <8.0%, *ideal <7.0%), (B) for blood pressure (<140/90 mmHg), (C) for cholesterol-non HDL (<160 mg/dL, *ideal <130 mg/dL), and (s) for smoking status (non-smoker).[135]

The HbA1c value is as follows; for a person without diabetes (<5.7%), prediabetes HbA1c values range from (5.7%–6.4%), controlled diabetes, HbA1c values are (=>6.5–7.9%), uncontrolled diabetes HbA1c value are (>8.0%).[136] The research study's clinical criteria set a higher range for patients with prediabetes HbA1c (=>5.7%–6.8%).

Several interconnected factors influence a person's ability to maintain or achieve targeted HbA1c ranges, such as increased age, heredity, a decline in self-efficacy, a reduction in cognitive, psychological, environment, social support, illness, infection, SDoH and SES factors.[50]

Lifestyle interventions also contribute to effective diabetes management and HbA1c control are; weight management– losing approximately 10 to 14 pounds (5% to 7%) of body weight, proper nutrition, physical activity–30 minutes/daily or 150 minutes/ week, controlled blood pressure ideally (<=120/80 mm/Hg), and maintaining cholesterol levels (< 200 mg/dL), sleep quality, stressors and tobacco use, also impact HbA1c control.[136,155,156] Diabetes management requires annual preventive screenings, such as kidney function tests, closely monitored blood pressure, updated immunizations, podiatry and optical examinations.[50,136]

Diabetes management, HbA1c control and timing

Two of the most significant components of diabetes management are the timing for when a person receives care and the ability to access healthcare services.[57,154,157] The failure to initiate, continue therapy, delay treatment, or miss appointments is known as therapeutic inertia,[97] clinical competence, or clinical inertia.[158,159,64] Therapeutic inertia is linked to deteriorating health outcomes leading to microvascular (involving small blood vessels–capillaries) and macrovascular (including large blood vessels–arteries and veins) complications.[160]

Microvascular complications include (retinopathy, nephropathy and neuropathy) and macrovascular (ischemic heart disease, peripheral vascular disease, and cerebrovascular disease).[160] These complications result in organ and tissue damage,[160] structural impairment – limb weakness, nerve damage, or functional impairment – loss of limbs or the ability of a body part to function correctly.[58,161]

Evidence-based clinical guidelines for reducing 95% of the potential micro and macrovascular complications in patients with T2DM are well-established, with continuous monitoring of blood glucose and HbA1c values by PCPs.[106,159,162] Well managed chronic disease reduces emergency room visits, hospitalizations, and healthcare costs, for improvement overall in population health outcomes.[45,52,161]

According to research TM facilitates timely, real-time monitoring, and mutual exchange of medical information between patient and provider,[92,51] and as effective as F2F visits.[97,163,164] Patients receiving the necessary timely PCP appointments, laboratory testing, medications, supplies, preventive screenings, achieve optimal HbA1c, and effective disease management.[97,155]

Patients with pre-existing physical and mental health disorders who missed two or more appointments annually had a threefold increased risk of all-cause mortality compared to those who did not miss appointments, according to a nationwide study in Scotland released in 2019.[165] Missing appointments by people with chronic conditions might be the difference between obtaining preventative care and early disease detection or late detection, which has higher mortality and morbidity risks.[20,165]

Fewer missed appointments translates to better patient-provider interactions, which can optimize patient adherence to the treatment plan and medication compliance.[20] Patients generally affected by SDoH and cost related non-adherence (CRN) often lack adequate resources, finances or ability to access healthcare services and are more likely to have poor disease management which can lead to disability due to delayed diagnoses and treatments.[97,161] CRN is linked to impaired physical functioning due to micro and macrovascular complications from poor diabetes management.[157]

Cost related non-adherence (CRN) related to SDoH factors

The conditions in which people are born, live, learn, work, play, worship, and age are known as SDoH, influencing the opportunities afforded to specific population groups based on geographical location, race, and ethnicity.[16,59] Multiple factors contribute to the complexity of managing disease including SDoH, SES, ethnicity, social support, personal efficacy, beliefs and cultural practices, food insecurity, mental health, and relationships with healthcare practitioners.[166] These factors often interact, resulting in a person's non-adherence to taking prescribed medications,[166] impeding their ability to achieve optimal glycemic control. Adherence to treatment protocol is when medication is taken 80% of the time.[166]

The 2013 National Health Interview Survey (NHIS) reported that 50% of adults with diabetes had financial stressors, financial deficiencies, and insecurity related to healthcare expenditures.[167] People with diabetes often have medical expenses up to three times higher than those without diabetes, as a result, they face difficulties adhering to PCPs' prescribed treatment plans.[168] According to studies, up to 40% of patients with diabetes medication non-adherence is related to costs (CRN).[169,170]

One-fifth of the NHIS survey participants reported food insecurity related to having limited or uncertain of the availability of nutritionally adequate or safe foods.[171] People living in SDoH areas have a high prevalence of food deserts, inadequate nutritional resources and limited financial resources, become food insecure are challenged with managing disease.[170,172,173] Monetary pressures frequently force people to employ cost-cutting methods by using alternative therapeutic practices in an effort to balance disease management and life necessities. Buying medications from other countries, adopting homeopathic remedies, taking smaller or less frequent medication dosages, postponing or avoiding therapeutic advice, or borrowing medications are some examples of cost-cutting tactics.[167,169] Frequent communication utilizing digital TM communication can raise the provider's awareness of patients' challenges, and connect them with social services averting potential CRN-related behaviors.

Conceptual framework– Veterans' Health Administration (VHA)

The conceptual framework that establishes the context for this research is based on the VHA's 21st century digital framework. Penchansky and Thomas theoretical model, developed in the 1980s, served as the foundation for the VHA's present conceptual framework designed to address healthcare access barriers in the 21st century among marginalized populations.[46,47] The VHA redesigned the Penchansky and Thomas' theoretical model,[48] as a more germane approach to healthcare access challenges in the 21st century digital/technological era.[61]

Penchansky and Thomas's model postulated five dimensions for improving healthcare access. The VHA's 21st century digital framework revised the Penchansky and Thomas's five dimensions of access – availability, accessibility, acceptability, affordability, and accommodation in service design. The VHA's adaptation of access is based on the degree of "fit" or match between the community, and the healthcare system which incorporates the geographical, temporal, financial, cultural, and digital constructs.[174]

The VHA is the largest integrated health-care delivery system in the US providing care for over 9 million veterans and over 1000 facilities nationwide.[174,91] The digital-based framework was developed to improve healthcare access for US veterans to meet the VA's mission "to care for [those] who should shall have borne the battle.[91(p1)]" The VHA Care Coordination Home Telehealth (CCHT) model integrates their pre-existing EHR, health informatics technology (HIT), home telehealth, and disease management technology.[61,73,175] The VHA's CCHT is a case management program based on the CDC Chronic Care Model (CCM) which was developed for unhoused senior veterans with chronic illnesses.[176]

Telehealth services and the CCHT model have been reported to be a cost-effective method of managing chronic disease and lowering hospitalizations among veterans.[176,177] Patients using telehealth technology increased by 1,500% in four years from 2003 to 2007,[177] and in 2021 increased to 3,147%,[175] with more than 11.2 million telehealth services.

A 2019 study based on Medical Expenditure Panel Survey (MEPS) data, revealed that the veteran patient population have similar risk factors as civilians identified as vulnerable and underserved. The similarities include limited financial resources, mental/physical disabilities, chronic health disorders,[178,179] inadequate transportation, reside in MUPA/UMUPAs, reduced number of service providers, geographical constraints, and the inability to schedule timely appointments.

The systemic, structural, financial, and logistical obstacles that frequently lead people to seek emergency room treatment are generally preventable with improved access to healthcare facilities and routine primary care visits.[91] The goals of TM are to improve healthcare delivery, reduce patient costs, improve accessibility, and expand access to services by minimizing patient-level barriers such as transportation, finances, time, and modifying system-level barriers such as scheduling, physician caseload and appointment availability. The VHA's five dimensions of healthcare access are described in the section below.

Five dimensions of healthcare access

(1) Geographical- *Accessibility*

The geographical construct includes the commuting distance to a healthcare facility's physical location, transportation constraints, and the population's residence.

(2) Temporal – *Availability*

The temporal construct is the time component associated with when patients require services and when they actually receive services. Timing is crucial for patients with chronic diseases because it has the potential to reduce the negative effects of therapeutic inertia.[47] The temporal construct also takes into account the time restrictions placed on doctors' that limit interactions with patients.

Time constraints may restrict PCPs in explaining vital health information which can result in misinterpretation of healthcare directives, particularly among patients with linguistic, literacy, hearing, speech challenges, and diverse cultural backgrounds.[11] Patients who are under time restrictions may be less able to provide complete and accurate information.

Providers' rely on clusters of information to make rapid medical diagnoses called gestalts defined as cognitive shortcuts.[11] When a provider lacks a patient's complete medical history, using gestalts to diagnosis a patient may lead to incorrect judgments causing medical errors. The interoperable functionality of TM makes patient records rapidly accessible, equipping PCPs with better decision-making tools.

(3) Financial –*Affordability*

The financial construct of access includes patients' costs related to health services, and healthcare insurance; (insurance premiums; eligibility requirements, and out-of-pocket expenses), and related expenses to care for family members, time off of work, and transportation requirements to attend to healthcare needs.

(4) Cultural –*Acceptability*

The cultural construct of access pertains to the 'fit' between the healthcare system, the patient and provider. This construct refers to the patient's readiness and acceptability in using technology for healthcare services based on demographics such as age, gender, language, educational level, race, ethnicity, background, and cultural norms. The patient's understanding of medical information may be influenced by the type of communication modality (in-person, videoconferencing, phone, and text messages), health literacy level, and the provider's ability to communicate using cultural competency and sensitivity.[11(p61)]

(5) Digital–*Accommodation*

The digital construct provides around the clock healthcare access by allowing physicians and patients to communicate via audio/video technology.[180] TM appointments include–digital connectivity; remote monitoring devices-camera, speakers, headphones, and health applications.

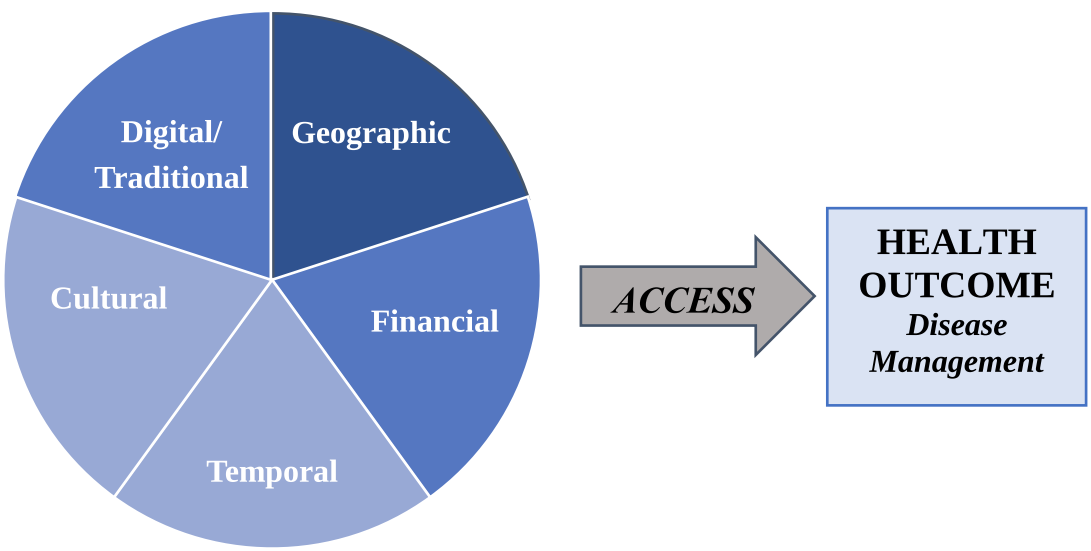
The VHA's 21st century framework was selected for its relevance in the current digital era; the success they achieved in caring for the unhoused veteran population; and its potential for future expansion to similarly vulnerable populations with healthcare access challenges. The framework is illustrated in Figure 2.1 below and described in Appendix C.

Figure 2.1

Conceptual Framework- The Five Dimensions of Healthcare Access

Veteran Health Administration (VHA)
21st Century Conceptual Framework
Telemedicine

* (adapted from Veteran's Health Administration)



Summary

The chapter discusses the history of TM, the burden of diabetes in high-risk vulnerable populations, SDoH factors, health inequities, and health disparities during a pandemic. The VHA's 21st century digital framework was the underpinnings for this study.

The purpose of this study was to determine the efficacy of utilizing TM for diabetes management in UMUPAs. The pandemic highlighted the necessity of a paradigm shift in the US healthcare delivery system to adopt new procedures for patient care service. TM provides an alternative to traditional healthcare delivery, allowing synchronous and asynchronous communication between patients and providers.

According to Public Health 3.0, tackling chronic diseases effectively is predicated on multi-sectoral collaboration.[36,181,182] Stakeholders must refrain from lapsing into organizational isolationism known as silos and commit to maintaining collaborative relationships by engaging in systems thinking, thus establishing long-term systemic and structural changes.[36,183]

CHAPTER III

METHODOLOGY

This chapter describes the research methodology, including the study design, population and sample size, measures and variables, instruments, data collection procedures, data analysis design, statistical analyses, and ethical considerations.

Study Design

The study analyzes electronic patient health records of T2DM patients with uncontrolled diabetes and prediabetes from January 1st, 2019, to June 30th, 2021, using a quantitative retrospective study design based on secondary data. Data from the UF CFMC EPIC MyChart Patient EHR were analyzed using bivariate correlation, bivariate linear regression and multiple linear regression (MLR) models. The EPIC EHR, a software repository for healthcare facilities that houses and manages patient's private health information for patients, was utilized to access data from patients' health records. The UF Health System's interface for electronic PHR's is called MyChart.

Data Source and Procedures

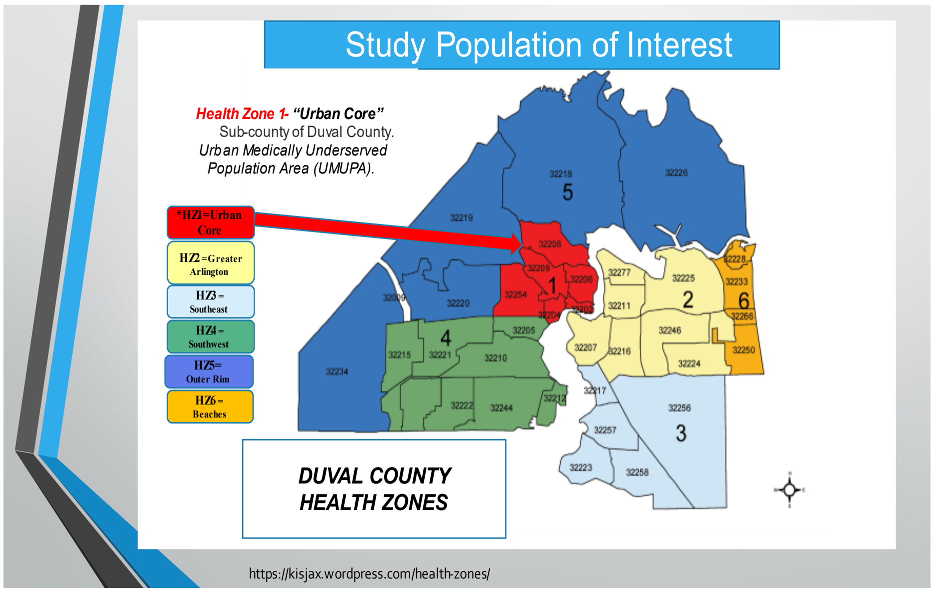
Data source

The EPIC MyChart EHR at UF Health Jacksonville CFMC served as the study's data source. The majority of the empaneled patients in the CFMC reside in a Duval County sub-county identified as HZ1, known as the "Urban Core" shown in the HealthZone map in Figure 3.1 below.

Figure 3.1

Duval County HealthZone Map

* (adapted from kisjax.wordpress.com)



The population is 80% African American and 49.5% have Medicaid as their insurer.[118] The residents of HZ1 have health challenges related to SDoH factors, high rates of obesity, poverty, prevalence of food deserts, lower SES, and lower literacy. The population is challenged with extensive health issues related to diabetes.[84,118] In 2019, Duval County had the third highest hospitalization rate for diabetes-related complications among Blacks in Florida, and the eighth highest count (33,842) among all population demographics in Florida.[178] Furthermore, hospitalization rates from diabetes-related complications was nearly twice for Black adults (4,904), compared to Whites adults (2,477).[184]

Procedures

The UF healthcare system initially collected data stored in an EHR system called EPIC MyChart to support clinical care delivery or health system operations. The quantitative retrospective study design was chosen due to the abundance of TM data that was initially collected for clinical purposes and was based on accessibility, availability, time restrictions, and cost effectiveness. Patients were selected based on diabetes-related ICD diagnosis codes E11 as the primary or secondary (i.e., second-listed) reason for the visit, dates of service from January 1st, 2019, to June 30th , 2021, and the type of healthcare service (TM or F2F).

The data collection process included a number of steps. A preliminary inquiry assessed TM utilization in the CFMC to establish the criteria and ascertain the availability of data for the specific research variables in T2DM patients. Convenience and purposive sampling were used in this research allowing for faster data acquisition, abstraction, and collection. Access to certain types of data for collecting patient health information was restricted by the pandemic.

UF Health personnel, who were familiar with the healthcare system's administrative, technical, and clinical procedures required for research, were consulted. A clinical, data warehouse–Integrated Data Repository (IDR) was used for collecting, aggregating, abstracting and organizing patient data from the UF EPIC–EHR system. The study protocol and sampling methodology were submitted to the IDR analyst, who was responsible for mining, abstracting, and collecting the required study variables from the electronic patient health records.

Routine communication occurred with the IDR analyst and the CFMC site clinicians to clarify ambiguous data, understand the clinic's coding methodology, define medical terminology, to ensure accurate interpretation for the EHR review process. Several IDR analysts were assigned to monitor and review the entire data abstraction and collection process for inter-rater reliability ensuring internal validity of the final results.

The final Excel datasets included de-identified recoded patient ID numbers, HbA1c lab values for each patient appointment, lab dates, deidentified service codes, provider type (title), race, age, ethnicity, gender, appointment status (missed or arrived), medical insurer, encounter type (TM or F2F), dates of service, and limited personal health information (PHI)–5-digit zip codes which were converted to HZ numbers.

Population and Sample

Sample

The primary data for the study was collected from the CFMC's archival database of T2DM electronic patient health records who received both types of healthcare services (TM and traditional care). The study sample included patients with prediabetes and uncontrolled diabetes to assess the efficacy of diabetes care, specifically analyzing changes in the HbA1c % values comparing TM to traditional care. Patients with well-managed (controlled) diabetes were not the focus of this investigation.

Inclusion criteria

The inclusion criteria were CFMC's patient medical records from January 1st, 2019 to June 30th, 2021, previously established adult patients 18 and over, enrolled in the UF electronic patient portal MyChart, with a clinical diagnosis of T2DM. The laboratory value was defined as HbA1c values. The healthcare service type was – (TM/virtual appointments and traditional/office visits). The patient's appointment status was coded either arrived or missed included–cancelled, left without being seen or no show.

Exclusion criteria

New patients were in the initial exclusion criteria; patients with up to three healthcare visits were included to capture patients with infrequent healthcare visits, therefore patients with fewer than three visits were excluded. Other exclusion criteria were patients with other diabetes types (gestational and Type 1), and patients with ICD-10 codes for endocrinology visits, nutritional and other medical/social service consultations, hospitalizations, and emergency room visits.

Measures/Variables

RQ1: Independent and Dependent Variables

A. The independent (predictor) variable for research question 1 is operationalized as:

(1). The ratio of TM-to-traditional visits–calculated by dividing the average number of TM appointments by the average number of traditional F2F visits.

B. The dependent (outcome) variable for research question 1 is operationalized as:

(1). The difference in mean HbA1c values for TM-to-traditional care visits in T2DM patients with uncontrolled diabetes HbA1c (=>8.0%): [For each patient, the average (mean) HbA1c for both TM and traditional visits was calculated. The final outcome variable was the difference in mean [HbA1c values for TM] and the [mean HbA1c values for traditional visits].

RQ2: Independent and Dependent Variables

A. The independent variable for research question 2 is operationalized as:

(1). The ratio of TM-to-traditional visits–calculated by dividing the average number of TM appointments by the average number of traditional F2F visits.

B**.** The dependent variable for research question 2 is operationalized as:

(1). The difference in mean HbA1c values for TM-to-traditional care visits in patients with prediabetes (=>5.7% – 6.8%). [For each patient, the average (mean) HbA1c for both TM and traditional visits was calculated. The final outcome variable is the difference in the [mean HbA1c values for TM] and the [mean HbA1c values for traditional visits].

Covariates

The sociodemographic covariates were operationalized as the patient's age, birth gender, race, ethnicity, provider type/title, medical insurer, appointment status, and 5-digit zip codes, were converted to six HZ numbers. The small patient populations in the six HZs required data aggregation which were recoded into four groups based on geographic proximity.

Age: This variable represents age in years as of the date of the visit encounter.

Gender: This variable is the birth gender of the research participants operationalized and recoded into two categories; the variable is operationalized as 1) female and 2) male. Female is the reference category coded as (1) when comparing the other category (male).

Race/Ethnicity: The patient demographic variable is operationalized into three groups: The variables are coded as: 1= African American/Black; 2= White; 3 = Asian/other. The variable Black is the reference category coded as (1) when comparing the other categories.

Medical insurer type: This variable was based on the patient's primary medical insurer/payer for the healthcare visit at the time service was rendered and categorized into three groups operationalized and recoded as Medicaid, Medicare, and Private (self-pay, private, other). The variables were recoded as 1) Medicaid, 2) Medicare, 3) Private/other. The variable Medicaid is the reference category coded as (1) when comparing the other categories.

HZs in Duval County defined by 5-digit zip codes: This variable HZ is operationalized as populations residing in Duval County initially recoded, identified, and numbered as HZs 1 through 6. The HZs were aggregated, recoded, renamed, and numbered 1 through 4 according to the geographical location, and to account for the small population sizes. 1)MUA HZ(Urban and Outer Rim) 2) Southwest HZ 3) Outer Duval HZ 4) Out of Perimeter/Area* (is not in any HZ). The MUA HZ was the reference category when comparing the other covariates.

The (1) MUAs HZ (n = 60%) includes HZ numbers 1–(Urban Core=52%), and 5–(Outer Rim=8%). These two HZs are populations residing in MUAs in Duval County, Jacksonville, Florida. (2) The Southwest HZ number 4 makes up (n = 32%) of the clinic's population. (3) The Outer Duval County (n = 12%) includes HZ 2– greater Arlington (n = 3%), HZ 3–Southeast (n =.8%), and HZ 6-Beaches area (n = .5%). (4) Out of Perimeter/Area (n = 4%) is located in another state or region in Florida.

Provider Type (Title): This variable is the title/type of provider conducting the patient visit operationalized as Medical Doctor (MD), Nurse Practitioner (NP), and Physician's Assistant (PA). The NP is the reference category coded as (1) when comparing the other categories.

Medical appointment information: The type of healthcare service (TM or F2F visits) and related service dates are included in this variable.

Appointment status: The patient's arrival status was recorded as: arrived, missed–canceled, or no show for the appointment date.

Statistical Methods

The first steps included cleaning, recoding and examining the primary dataset for missing data and outliers. After examination of the data, imputation was performed on seven missing lab values, and twenty-one patients were removed because they did not fit the criteria and had appointments outside of CFMC. The final baseline cohort resulted in 366 patients with 3749 clinic visits and analyzed using descriptive statistics including frequencies, and percentages. The categorical data were gender, race, ethnicity, HZ, type of healthcare service visit, provider title/type, medical insurer, appointment status, and the median patient age.

The next step was identifying and subdividing the primary dataset into four separate data subsets based on patient's HbA1c % values. The four extracted data subsets included two datasets for patients with uncontrolled diabetes (=>8.0%) and two datasets for patients with prediabetes (=>5.7%–6.8%). The final step compiled the multiple patient records and visits into one unique ID patient-level variable. The HbA1c values were converted into a single number as the mean HbA1c % values, and visits were classified by appointment type (TM or traditional).

The independent and primary outcome variables in both research questions are continuous, therefore correlations were used to examine their relationship, reporting the correlation coefficient and the p-value for each question. Then, for each RQ, a regression model was created to determine how the independent variable predicts the dependent variable. Data were summarized using means, SD, ranges (minimum, maximum) for continuous variables, and percentages for categorical data.

The assumption tests for normality using Shapiro-Wilk assessed the relationship between the ratio TM/F2F and the difference in mean HbA1c values. The null hypothesis for this test is that the outcome variable is normally distributed. The p-value for the Shapiro-Wilk test is < 0.05 indicating that the normality assumption is met.

Data Analysis Plan

Pearson correlation:

A Pearson r correlation is the appropriate bivariate statistic when both input variables are continuous and assumes a linear relationship.[185] The value that measures the strength of linkage between two variables in a single variable between -1 and +1 is the correlation coefficient. [185] Correlation coefficients, vary from 0 (no relationship) to 1 (perfect linear relationship) or -1 (perfect negative linear relationship).[186] Positive coefficients indicate a direct relationship, as one variable increases, the other variable also increases.[187] Negative correlation coefficients indicate an inverse relationship, as one variable increases, the other variable decreases.[188]

Examination of the relationship between the independent and dependent variables was performed by a one-tailed Pearson correlation and the level of significance is set at 5%. A one-tailed p-value less than 0.05 would indicate a significant inverse association between the ratio TM/F2F and the difference in mean HbA1c values.

Cohen's standard:

Cohen's standard was used to evaluate the correlation coefficient, where 0.10 to 0.29 represents a small association between the two variables, 0.30 to 0.49 represents a moderate association, and 0.50 or larger represents a strong association.[188]

Statistical Analysis Models

Bivariate linear regression, bivariate correlation and MLR Models

A one-tailed bivariate correlation was conducted for RQ1 and RQ2 based on alpha value .05 for variables difference in mean HbA1c values and ratio TM/F2F. This research examined two bivariate linear regression models analyzing patients with uncontrolled diabetes and prediabetes to predict the effect of the predictor ratio TM/F2F on the dependent variables [difference in mean HbA1c values]. All covariates that had more than two categories were dummy coded and analyzed in the MLR models.

Multiple Linear Regression Analysis (MLR)

The MLR is a predictive analysis and the most common type of linear regression model. [187,189] A MLR model implies there is a correlation between the continuous or categorical predictors and the continuous dependent variable. It then predicts the dependent variable by creating a linear model of all predictor variables assigned with a unique regression coefficient.[187,189] The coefficient of determination r^2 statistic interprets how well the regression model predicted the dependent variable. The unstandardized correlation coefficient describes the increase or decrease of the independent variables in relation to the dependent variable.[187]

MLR–Patients with uncontrolled diabetes

The first MLR model for the RQ1 patients with uncontrolled diabetes *study specific variables* analyzed the relationship between the primary predictor ratio TM/F2F and covariates analyzing the relationship between the dependent variable [difference in mean HbA1c values] evaluating the effect of the [primary predictor ratio TM/F2F and covariates age, gender, race, HZs]. The second MLR model for patients with uncontrolled diabetes *visits*, analyzing the relationship between the dependent variable [HbA1c % values] evaluating the effect of the covariates [gender, race, HZ, medical insurance, healthcare service type, and provider type/title].

MLR–Patients with prediabetes

The first MLR model for RQ2 patients with prediabetes, *study specific variables* analyzing the relationship between the dependent variable [difference in mean HbA1c values] evaluating the effect of the [primary predictor ratio TM/F2F and covariates age, gender, race, HZs]. The second MLR model for patients with prediabetes *visits*, analyzing the relationship between the dependent variable [HbA1c % values] evaluating the effect of the covariates [gender, race, HZ, medical insurance, healthcare service type, and provider type/title].

The predictor variables excluded from the MLR study specific analyses were provider type, and medical insurer due to patients having multiple providers, and medical insurers, therefore data aggregation for patients and variables was not possible. The predictor healthcare service types were also excluded because they were included in the ratio TM/F2F.

Ethical Approvals

Institutional review boards (IRBs) at each site – the UF Health System IRB 01 and Georgia Southern University exemption 4-(limited review) approved the study protocol. Exempt status for chart reviews were approved for secondary PHR data collection. The data collected was archival, retrospective, which was originally collected by UF Health EHR EPIC for "healthcare operations" according to 45 CFR 164.512(b).

The UF IRB 01 exempt status is defined as secondary research for which consent was not required. The study did not involve participants enrolled in experimental protocols and should pose minimal risk to administrative health professionals or patients. The data was de-identified by the IDR and submitted to study team via a secure server and stored on an institutional server, that is encrypted and double password protected. The final IRB approval documentations are in (Appendix A). All statistical analyses were performed by SPSS 27 or a comparable software program.

This chapter described the methodology of the study design, research question variables, data collection, a description of the sample population, data analyses, and ethical considerations.

CHAPTER IV

RESULTS

This chapter describes the research results, descriptive statistics, demographics, assumption testing, data analyses of the research questions with the associated hypotheses using bivariate and multiple linear regression models, and summary of the findings.

This research examined the association between the ratio of healthcare service visits via TM or F2F mode of care and the difference in mean HbA1c values for ratio TM/F2F in T2DM patients with uncontrolled diabetes (=>8.0%) and patients with prediabetes (5.7%–6.8%), during the study period from January 1st, 2019 to June 30th, 2021. Data was collected from retrospective patients ‘medical records from January 1st, 2019 to June 30th, 2021 from patients of the Commonwealth Family Medicine Clinic (CFMC). The original dataset results yielded 387 patients who received 3763 visits. Following an analysis of the dataset, imputation was done on seven missing lab values, twenty-one patients were removed because they did not meet the criterion, leaving 366 patients with 3749 clinic visits as the final baseline cohort.

The new dataset was separated into four groups to analyze the research questions study variables based on the patients' HbA1c percentages for uncontrolled diabetes and prediabetes. Patients with uncontrolled diabetes were divided into two groups based the unique patient IDs (n = 111) and the total number of healthcare service visits, TM and F2F visits (n=1685). Patients with prediabetes were also divided into two groups based on the unique patient ID numbers (n = 81) and the total number of healthcare service visits, TM and F2F (n = 634). Two separate units of analyses were employed to measure the *difference in mean HbA1c values* for the unique ID patient level data; and *HbA1c% values* for the number of patient visits, respectively.

The study used two bivariate correlation models, two bivariate linear regression models and four MLR models for data analyses. The bivariate correlation and bivariate linear regression models analyzed the relationship between the outcome variable–difference in mean HbA1c values and predictor variable–ratio TM/F2F. The four MLR models for patients with uncontrolled diabetes and prediabetes evaluated the effect of the covariates (predictors) on the dependent variables [difference in mean HbA1c values and HbA1c% values], respectively.

The first two MLR models analyzing the [difference in mean HbA1c values] for the RQs *study variables* and the [primary predictor–(ratio TM/F2F) with the covariates–age, gender and HZ] for patients with uncontrolled and prediabetes, respectively. The next two MLR models analyzing the [HbA1c % values] for *patient visits* with covariates [age, gender, race, provider type, healthcare service visit, type of medical insurer, and HZs].

Due to patients seeing multiple providers, and having more than one medical insurer, data aggregation was not possible, therefore the predictors [provider type and medical insurer] were not included in the RQ1 and RQ2 MLR models. The key predictor variable ratio TM/F2F contained both healthcare services, hence the [healthcare service visit types] were also omitted.

Descriptive Statistics

The descriptive statistics of the categorical variables [gender, race, ethnicity, HZs, provider type/title, and medical insurer] were reported in frequencies and percentages for 366 patients, and 3749 visits. Female patients (*n* = 2342, 62.47%) had the highest number of healthcare visits, and males (n = 1407, 38%) had the lowest number of visits. The highest category for race was Black (*n* = 2708, 72.23%), followed by White (n = 940, 25%), and other/Asian (n = 101, 3%) which was excluded from the final analysis due to small percentages. Non-Hispanic was the highest ethnicity category (n = 3649, 97%) and Hispanics were the lowest number of patients (n = 100, 3 %). Patients with uncontrolled diabetes (*n* = 1950, 52.01%) had the highest number of appointments, followed by patients with controlled diabetes (n = 1091, 29 %), and prediabetes (n = 515, 14%). The nurse practitioner (NP) was the provider who saw the highest number of patients (n = 2039, 54.39%), followed by the medical doctor (MD) (n = 903, 24%), and the physician's assistant (PA) (n = 807, 22%). The two primary forms of medical insurers used by patients were equivalent [Medicare (n = 1585, 42.28%) and Medicaid (n = 1563, 42%)], while the least number of patients (n = 601, 16%) utilized private insurance. The mean age of all patients in the original cohort was 57.2 years (SD = 11.34).

A. Uncontrolled diabetes: Demographics patient *visits* (n = 1685)

The RQ1 data subset for *patients with uncontrolled diabetes*, originally yielded (163 unique IDs, 1896 visits); of which (52 patients, 211 visits) were excluded due to either missed appointments and/or not receiving both types of healthcare service visits (TM and F2F). After cases were excluded, the final results were [111 unique ID patients and 1685 visits].

The demographics reporting the highest numbers and percentages were Black (*n* = 1234, 73.23%), non-Hispanic (*n* = 1668, 98.99%), female (*n* = 1014, 60.18%) patients living in HZ MUAS (*n* = 917, 54.42%), the highest number of visits were with the NP (*n* = 1087, 64.51%). Medicaid (*n* = 698, 41%) was the most common type of medical insurance. Patients used both types of healthcare visits equally F2F visits (*n* = 843, 50.03%) and TM appointments (n=842, 49.97%).

The frequencies and percentages for the number of visits for all patients with uncontrolled diabetes n=1685 are displayed below in Table 4.1 includes the categorical variables–gender, race, ethnicity, HZs, provider type/title, and medical insurer.

Table 4.1

Descriptive Statistics T2DM Patients with Uncontrolled Diabetes–Visits (N =1685)

Variable Ethnicity	N	%
Hispanic	17	1.01
Non-Hispanic	1668	98.99
Provider type/title		
MD	272	16.14
PA	326	19.35
NP	1087	64.51
Gender		
Male	671	39.82
Female	1014	60.18
HealthZones		
Outer Duval	65	3.86
Out of Area*	87	5.16
SW	616	36.56
MUAs	917	54.42
Race		
Other	30	1.78
White	421	24.99
Black	1234	73.23
Medical Insurer		
Private	291	17.27
Medicare	696	41.31
Medicaid	698	41.42

Note: adapted from www.intellectus.com. abbreviation N = number of unique patients with uncontrolled diabetes. Asterisk* indicates not an official HZ.

B. Demographic statistics: Patients with uncontrolled diabetes *unique IDs* (n=111) *RQ1*

The descriptive statistics, frequencies, and percentages for RQ1 unique IDs patient level categorical variables gender, race, ethnicity, and HZs are displayed in table 4.2 below. The highest numbers and percentages were identified as Black (n = 84, 76%), non-Hispanic (n = 109, 98.2%), females (n = 73, 66%), had the highest number of visits, and reside in the MUA HZs (n = 62, 56%) and the mean age was 54.3, (SD = 11.64).

Table 4.2

Descriptive Statistics T2DM Patients with Uncontrolled Diabetes–Unique ID's (N=111, RQ1).

Variable	N	%
Race		
Other	3	2.70
White	24	21.62
Black	84	75.68
Ethnicity		
Hispanic	2	1.80
Non-Hispanic	109	98.20
Gender		
Male	38	34.23
Female	73	65.77
HealthZones		
Outer Duval	6	5.41
Out of Area*	7	6.31
SW	36	32.43
MUAs	62	55.86

Note: adapted from www.intellectus.com. abbreviation N = number of unique patients with uncontrolled diabetes. Asterisk* indicates not an official HZ.

C. Prediabetes: Demographics all patient visits (n = 634)

The RQ2 data subset for *patients with prediabetes* originally yielded (140 unique IDs, and 771 visits); of which 59 patients were excluded because of missed visits and/or did not have both types of healthcare service visits (TM and F2F). After exclusion of all cases, the final number use for analyzing the RQ2 study variables resulted in [81unique ID patients and 634 visits].

The demographics reporting the highest numbers and percentages for *patients with prediabetes* were Black (*n* = 416, 66%), Non-Hispanic (n = 599, 94.5%), female (*n* = 463, 73%), living in the MUA HZs (*n* = 328, 52%), and had the highest number of visits with the NP (*n* = 310, 49%). The healthcare service visits were approximately equal F2F visits (*n* = 323, 50.95%) and TM appointments (*n* = 311, 49.05%) and Medicare (*n* = 306, 48.3%) was the most common type of medical insurance. The mean age of the patients was 59.4 years (SD) = 11.65.. Frequencies and percentages for categorical variables of all patients with prediabetes visits n = 634 are displayed in Table 4.3 below.

Table 4.3

Descriptive Statistics Patients with Prediabetes–Visits (N=634)

Variable	N	%
Ethnicity		
Hispanic	35	5.52
Non-Hispanic	599	94.48
Provider type/title		
PA	149	23.50
MD	175	27.60
NP	310	48.90
Gender		
Male	171	26.97
Female	463	73.03
HealthZones		
Out of Area*	27	4.26
Outer Duval	48	7.57
SW	231	36.44
MUA	328	51.74
Race		
Other	35	5.52
White	183	28.86
Black	416	65.62
Type of healthcare service visit		
Telemedicine	311	49.05
Traditional office visit	323	50.95
Medical Insurer		
Private	89	14.04
Medicaid	239	37.70
Medicare	306	48.26

Note: adapted from www.intellectus.com. abbreviation N = number of visits patients with prediabetes. Asterisk* indicates not an official HZ.

D. Demographic statistics: patients with prediabetes unique IDs (n=81) *RQ2*

The descriptive statistics, frequencies, and percentages for RQ2 unique patient level categorical variables gender, race, ethnicity, and HZs are displayed in table 4.4 below. The highest numbers and percentages were identified as Black (n = 54, 67%), non-Hispanic (n = 79, 98%), females (n = 59, 73 %) had the highest number of visits and resided in the MUA HZ (n = 52, 64%), and mean age was 58.11, (SD = 12.98).

Table 4.4

Descriptive Statistics Patients with Prediabetes–Unique ID's (N = 81, RQ2)

Variable	N	%
Race		
Other	7	8.64
White	20	24.69
Black	54	66.67
Ethnicity		
Hispanic	2	2.47
Non-Hispanic	79	97.53
Gender		
Male	22	27.16
Female	59	72.84
HealthZones		
Outer Duval	5	6.17
Out of Area*	6	7.41
SW	18	22.22
MUA	52	64.20

Note: adapted from www.intellectus.com. abbreviation N = number of unique patients with prediabetes. Asterisk* indicates not an official HZ.

Assumption tests for analyses

Assumption tests were used to determine if the data was normally distributed, if the groups have similar variances, and independent of one another.

Shapiro-Wilk

Before conducting analyses, the first step was to ensure that assumptions were met.

Both research questions were evaluated with the same assumption testing. The first test was Shapiro-Wilk to determine whether the distributions of the variables [ratio TM/F2F, and the difference in mean HbA1c] significantly differed from normality.

Pearson correlation.

A Pearson correlation is the appropriate bivariate statistic when both input variables are continuous and assumes a linear relationship.[185] The correlation coefficient is the value that measures the strength of linkage between two variables in a single variable between -1 and +1. Examination of the relationship between the independent and dependent variables was performed by a one-tailed Pearson correlation and the level of significance was set at 5%. A one-tailed p-value less than 0.05 indicates a significant inverse association between the [ratio TM/F2F] and the[difference in mean HbA1c values. Parametric testing was used to analyze RQ1 and RQ2 variables, and regression models will be conducted for RQ1 and RQ2.

The assumption tests for regression models include scatterplot tests for normality, indicating how well the data resembles a bell-shaped curve, homoscedasticity, which looks for random scatter, and the absence of multicollinearity, which ensures that predictors are not highly related.[187]

Homoscedasticity:

Homoscedasticity compares the degree to which different groups are equal or similar. Homoscedasticity was met–indicating the points were randomly distributed with no apparent curvature.[190,191]

Multicollinearity:

A multicollinearity test was used to determine whether or not several independent variables in a model are correlated. When independent variables have multicollinearity, statistical inferences with a larger standard of error incur less reliable results.[192] When a MLR model has two or more variables, it is preferable to use independent variables that are not correlated or repetitive.[192] Variance Inflation Factors (VIFs) were calculated to detect the presence of multicollinearity between predictors and ensure that they are not highly related to one another.[186] The predictors used in the regression models had VIFs less than 5 indicating collinearity is not a significant issue. The general rule is VIF values exceeding 10 indicates a problem with collinearity.

Statistical Analyses

Research Question 1- *Patients with Uncontrolled Diabetes RQ1*

I. Bivariate Linear regression and correlation models was conducted for the difference in mean HbA1c values and ratio TM/F2F visits.

RQ1 asked is there an association between the ratio of healthcare service visits via TM-to-traditional mode of care and the difference in mean HbA1c values for TM/F2F in T2DM patients with uncontrolled diabetes (=>8.0%), during the study period from January 1st, 2019 to June 30th, 2021?

The dependent (outcome) variable *difference in mean* was calculated by: subtracting the [mean HbA1c values F2F] from the [mean HbA1c values for TM] represented by the equation: [HbA1c TM - HbA1c F2F]. The independent (predictor) variable *ratio of TM-to-traditional visits* was calculated by: the [number of TM appointments–*numerator*] divided by the [number of F2F visits–*denominator*] represented by the equation: [TM/F2F]. When the numerator (TM) is greater than the denominator (F2F) the ratio TM/F2F visits is interpreted as patients having a higher number of TM.

The bivariate correlation table 4.5 and bivariate linear regression table 4.6 models indicated that there was a significant correlation, and an inverse linear relationship between the difference in mean HbA1c values and the ratio TM/F2F for T2DM patients with uncontrolled diabetes.

The RQ1 bivariate linear regression model was $F(1,109)$, $p = .034$, $R^2 = .021$ demonstrates significant results using a one-tailed test (B = -.074, $p = .034$). Suggesting that TM appointments compared to F2F visits were more likely to have a -.074 lower difference in mean HbA1c value.

The bivariate regression model illustrated by the graph in Figure 4.1 below, denotes the linear relationship between the ratio TM/F2F visits and the difference in mean HbA1c values.

Figure 4.1

Graph-Bivariate Linear Regression Model Analyzing the Difference in Mean HbA1c Values and Ratio TM/F2F–T2DM Patients with Uncontrolled Diabetes–(RQ1).

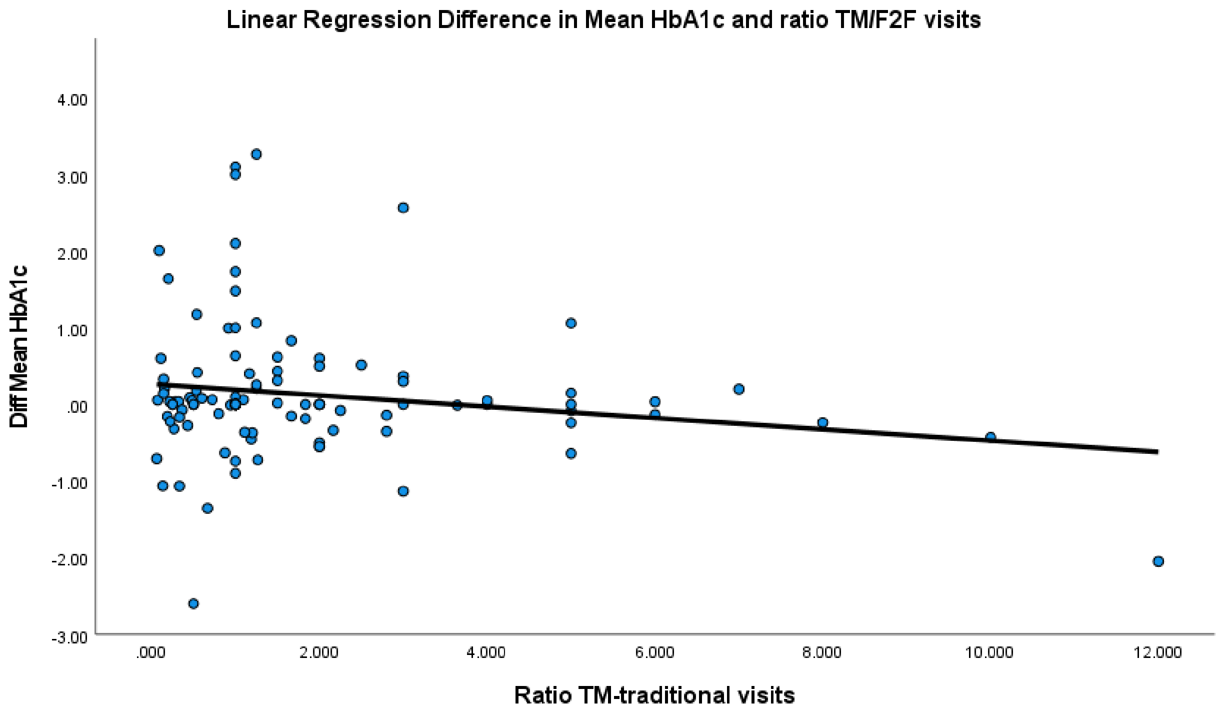


Table 4.5

Bivariate Correlation Difference in Mean HbA1c and Ratio TM/F2F–T2DM–Patients with Uncontrolled Diabetes (RQ1).

Correlations		Difference in mean HbA1c	Ratio TM/F2F
Difference in mean HbA1c	Pearson Correlation	1	-.174*
	Sig. (1-tailed)		**.034**
	N	111	111
Ratio TM/F2F	Pearson Correlation	-.174*	1
	Sig. (1-tailed)	**.034**	
	N	111	111

Note: *Correlation is significant at the p = 0.05 level (1-tailed). Bold indicates statistical significance.

Table 4.6

Bivariate Linear Regression Difference in Mean HbA1c and Ratio TM/F2F–T2DM Patients with Uncontrolled Diabetes (RQ1).

Variable	Unstandardized Coefficients B	Std. Error	T	Sig.
Difference in mean HbA1c values	.266	.108	2.470	.015
Ratio TM/F2F	**-.074**	.040	-1.842	**.034**

Note: Significance is set at the p = 0.05 level (1-tailed). Bold indicates statistical significance

The RQ1 null hypothesis was rejected that stated–There is NO association between the ratio TM/F2F and the difference in mean HbA1c values for TM/F2F visits in T2DM patients with uncontrolled diabetes.

The summary statistics of the RQ1 study variables in *patients with uncontrolled diabetes* analyzing the dependent variable [difference in mean HbA1c values] was 0.13 (SD= 0.86), (range -2.6 to 3.27). The mean for the independent variable ratio [TM/F2F] was 1.77 (SD = 2.02), (range .063 to 12).

II. MLR RQ1: Patients with uncontrolled diabetes [difference in mean HbA1c]

The first MLR model analyzed the RQ1 study specific variables in *patients with uncontrolled diabetes* results were not significant, $F(6,104) = 1.673$, $p = .135$, $R^2 = .088$ indicating that the primary predictor ratio TM/F2F, and covariates–age, gender, race, and HZs did not explain a significant proportion of variation in the difference in mean HbA1c. Although the *p*-value for the overall model was not significant, after controlling for the other covariates, the variable representing the ratio TM/F2F was significant, suggesting that the ratio TM/F2F

(B = -.086, *p* = .036) visits had an inverse correlation with an 8.6% lower value for the difference in mean HbA1c % value. The R^2 for the overall model reports an effect size 8.8%. The results are displayed in Table 4.7 below.

Table 4.7

Multiple Linear Regression Model Analyzing Difference in Mean HbA1c Values and Predictors–T2DM Patients with Uncontrolled Diabetes (RQ1).

	Unstandardized Coefficients			
Variable	B	Std. Error	t	Sig.
Difference in mean HbA1c values	1.390	.476	2.922	.004
Ratio TM/F2F	**-.086**	.041	-2.123	**.036**
Gender-Female	-.294	.173	-1.699	.092
Race-Black	-.043	.191	-.224	.823
Age	-.012	.007	-1.705	.091
HZ Southwest	-.051	.177	-.288	.774
HZ Outer Duval	-.125	.371	-.338	.736

Note. Results: $F(6,104) = 1.673$ $p = .135$, $R^2 = .088$. Bold indicates statistical significance. Unstandardized Regression Equation: difference in mean HbA1c = 1.390, + Ratio TM/F2F*(-.086), + Gender (-.294) + Age (-.012), + Black (-.043) + HZ SW (-.051) + HZ Outer Duval (-.125).

III. MLR patients with uncontrolled diabetes [HbA1c %] *visits*

The second MLR model analyzed HbA1c % values and covariates [age, gender, race, provider type/title, healthcare service, medical insurer, and HZs] for *patient visits*. The MLR model results presented below in table 4.8 were significant $F(8,1676) = 25.781$, $p < .000$, $R^2 = .105$, indicating that approximately 10% of the variance in HbA1c values is explainable by [age, gender, race, HZs, healthcare service type (TM), and medical insurance Medicaid. The R^2 for the overall model was 10.5%.

Table 4.8

Multiple Linear Regression Model Analyzing HbA1c % Values and Covariates–T2DM Patients with Uncontrolled Diabetes–Visits.

	Unstandardized Coefficients			
Variable	B	Std. Error	t	Sig.
(HbA1c %)	11.588	.307	37.765	.000
Age	**-.026**	.004	-5.863	**.000**
Gender-Female	**.190**	.090	2.122	**.034**
Race-Black	**.888**	.097	9.117	**.000**
Provider Type/title-NP	.006	.089	.072	.942
Healthcare-TM	**-.339**	.086	-3.957	**.000**
Insurer-Medicaid	**-.612**	.097	-6.286	**.000**
HZ SW	**.617**	.093	6.638	**.000**
HZ Outer Duval	**-.602**	.225	-2.678	**.007**

Note-Results: MLR model were significant F(8,1676) = 25.781, p < .000, R^2 = .105.
Bold indicates statistical significance.
Unstandardized Regression Equation: HbA1c = 11.588 + age* (-.026) + Gender-Female* (.190) + Race-Black (.888)* + NP (.006) + Healthcare service-TM* (-.339) + Medicaid* (-.612) + HZ SW* (.617) + HZ Outer Duval* (-.602).

The healthcare service type TM significantly predicted HbA1c % values, B = -.339, *p* < .000 after controlling for the covariates in this model, this suggests that patients using TM more likely have 34% lower HbA1c % values on average when compared to F2F visits. After controlling for the covariates in this model, the gender category-female, B = .190, *p* < .034 was significant when compared to males in predicting HbA1c % values, suggesting that females on average are more likely to have 19% higher HbA1c % values. Age was a significant predictor of HbA1c% values, B = -.026, *p* < .000. After controlling for the covariates in this model the race Black, B = 888, *p* < .000 was a significant predictor of HbA1c % values. Suggesting that Black adults on average are more likely to have an 88.8% higher HbA1c value when compared with White adults.

After controlling for the covariates in this model the HZ SW, B = .617, $p < .000$ significantly predicted HbA1c % values. Suggesting that HZ SW compared to the MUA HZs were on average more likely to have 61.7% higher HbA1c value. The HZ outer Duval County was significant. B = -.602, $p < .007$ when compared to the MUA HZs and were on average more likely to have 60.2 % lower HbA1c values. After controlling for the covariates in this model the type of healthcare provider NP, B = .006, $p = .943$ was not significant when compared with other healthcare providers. After controlling for the covariates in this model the type of medical insurer Medicaid, B = -.612, $p < .000$ was significant. This suggests that patients with Medicaid when compared to Medicare as their medical insurer on average have 61.2% lower HbA1c values.

Summary: The MLR model for *patients with uncontrolled diabetes* indicated there was a significant, *negative* association between age, healthcare service type TM, medical insurer-Medicaid, and the HZ Outer Duval County. Gender, race, and HZ SW had a significant *positive* association with HbA1c % values. The provider type was not statistically significant.

Research Question 2- *Patients with Prediabetes RQ2*

IV. Bivariate correlation and bivariate regression models–difference in mean HbA1c values and TM/F2F visits.

Research question 2 asked– Is there an association between the ratio of healthcare service visits via TM-to-traditional mode of care and the difference in mean HbA1c values for TM-to-traditional office visits in *patients with prediabetes* (=>5.7% – 6.8%), during the study period from January 1st, 2019 to June 30th, 2021?

Bivariate correlation table 4.9 and bivariate regression table 4.10 models presented below were conducted for RQ2 the difference in mean HbA1c values and the ratio TM/F2F visits. The results of the RQ2 1-tailed, bivariate linear regression model *F*(1,79), $p = .227$, $R^2 = -.005$ and the bivariate correlation ($p = .227$) were not statistically significant.

Therefore, the null hypothesis H_0 was not rejected, indicating there is NO association between the ratio of TM-to-traditional office visits and the difference in mean HbA1c values for TM-to-traditional care visits in patients with prediabetes (>=5.7–6.8%).

The summary statistics of the RQ2 for the dependent variable [difference in the mean HbA1c] had a mean of 0.14 (SD= 0.17), and (range -.80 to .50), and the mean for the independent variable [ratio TM/F2F] was 1.55 (SD = 1.57), (range .08 to 9). Tables 4.10 below reports the bivariate regression model for the RQ2 variables [difference in the mean HbA1c] and [ratio TM/F2F].

Table 4.9

Bivariate Correlation Analyzing Difference in Mean Hba1c Values and Ratio TM/F2F–Patients with Prediabetes (RQ2).

Variable		Ratio TM/F2F	Difference in mean HbA1c
Ratio-TM/F2F	Pearson Correlation	1	-.084
	Sig. (1-tailed)		.227
	N	81	81
Difference in Mean HbA1c values	Pearson Correlation	-.084	1
	Sig. (1-tailed)	.227	
	N	81	81

Note: The (1-tailed) bivariate correlation model was not significant. P value = .227

Table 4.10

Bivariate Linear Regression Analyzing Difference in Mean HbA1c Values and Ratio TM/F2F–Patients with Prediabetes (RQ2).

	Unstandardized Coefficients			
Variable	B	Std. Error	T	Sig.
Difference in Mean HbA1c values	-.001	.027	-.032	.974
Ratio TM/F2F	-.009	.012	-.754	.227

V. MLR RQ2: Patients with prediabetes [difference in mean HbA1c % values]

The first MLR was analyzed the RQ2 study specific variables [difference in mean HbA1c values] and the primary predictor [ratio TM-to-traditional office visits, and covariates, age, gender-female, race, and HZs (SW, and Outer Duval County). The results of the first MLR for the RQ2 study variables model were not significant, $F(6, 74) = 1.337$, $p = .503$, $R^2 = .068$, indicating ratio TM/F2F, age, race, gender, and HZs did not explain a significant proportion of the variation in difference in mean HbA1c values. The R^2 for the overall model reports a 6.8 % effect size. *Table 4.11* displayed below summarizes the results of the MLR model.

Table 4.11

Multiple Linear Regression Analyzing Difference in Mean HbA1c Values and Predictors–Patients with Prediabetes–Unique ID's (RQ2).

	Unstandardized Coefficients			
Variable	B	Std. Error	T	Sig.
Difference in mean HbA1c values	-.108	.106	-1.025	.309
Ratio TM/F2F	-.008	.013	-.645	.521
Gender-Female	-.022	.045	-.501	.618
Age	.002	.002	1.433	.156
Race-Black	.030	.041	.738	.463
HZ Southwest	-.072	.047	-1.535	.129
HZ Outer Duval	.025	.083	.298	.767

Note-Results: The overall MLR model was not statistically significant F (6,74) = .895, p = .503, R^2 = .068
Unstandardized Regression Equation: difference in mean HbA1c values = (-.108) + Ratio TM//F2F(.008) + Gender-female (-.022) + age + (.002) + race-Black (.030) + HZ SW (-.072) + HZ Outer Duval (.025).

VI. MLR patients with prediabetes *visits* [HbA1c % values]

The second MLR model analyzed HbA1c % values and covariates [age, gender, race, provider type/title, healthcare service, medical insurer, and HZs] for *patient with prediabetes visits*. The results of the second MLR model presented below were significant F(8, 634) = 8.842, p < .000, R^2 = .100. The R^2 for the overall model reports an effect size .100 indicating that approximately 10% of the variance in HbA1c % values is explainable by predictors [age, race, HZs, and medical insurer].

After controlling for the other covariates in this model, the gender female B = .016, p = .626 was not significant when compared to males. This suggests that gender does not have a significant effect on HbA1c % values. After controlling for the other covariates in this model, age, B = .006, p < .000 was significant. This indicates that on average, a one-year increase in age will likely have a .6 % higher HbA1c % values. After controlling for the other covariates in this model the Black adults, (B = -.062, p = .030) when compared to White adults was significant. This suggests that Blacks were on average more likely to have 6.2% lower HbA1c % values when compared with Whites. After controlling for the other covariates in this model the healthcare service type TM, (B = -.042, p = .102) when compared to traditional visits was not significant. This suggests that the healthcare service type traditional visits does not have a significant effect on HbA1c % values. After controlling for the other covariates in this model the HZ SW when compared with MUA HZs was a significant predictor of the HbA1c% values, (B = .086, p = .005), suggesting that residents in HZ SW are on average more likely to have an 8.6 % higher HbA1c value compared to residents in the MUA HZs. The HZ Outer Duval County, (B = .027, p = .618) when compared with MUA HZs was not significant.

After controlling for the other covariates in this model, the provider type NP, (B = .008, p < .763) was not significant when compared with other healthcare providers. After controlling for the covariates in this model the type of medical insurer Medicaid, (B = .237, p <.000) is significant when compared with Medicare. This suggests that patients with Medicaid will likely have 23.7% higher HbA1c% values when compared to Medicare.

Summary: The MLR model for *patients with prediabetes* indicates a significant, *negative* association with race and HbA1c % values. The medical insurer-Medicaid, and HZ Southwest had a significant *positive* association with HbA1c % values. The predictors gender, healthcare service TM, HZ Outer Duval, and provider type NP, were not statistically significant.

Table 4.12 below presents the MLR HbA1c % values and covariates gender, age, race, healthcare service type, provider type, HZs- (SW, Outer Duval County), medical insurer Medicaid.

Table 4.12

Multiple Linear Regression Analyzing HbA1c % Values and Covariates–Patients with Prediabetes–Visits.

Variable	Unstandardized Coefficients B	Std. Error	t	Sig.
HbA1c % values	5.880	.099	59.618	.000
Gender-Female	.016	.032	.488	.626
Age	**.006**	.001	4.541	**.000**
Race-Black	**-.062**	.029	-2.171	**.030**
Healthcare type-TM	-.042	.026	-1.639	.102
HZ Southwest	**.086**	.031	2.796	**.005**
HZ Outer Duval	.027	.053	.499	.618
Provider type-NP	.008	.028	.301	.763
Insurer-Medicaid	**.237**	.034	7.010	**.000**

Note-Results: MLR model were significant *F* (8, 634) = 8.842, $p < .000$, $R^2 = .100$ Bold * statistical significance p < .000. Dependent variable HbA1c % value.
Unstandardized Regression Equation: HbA1c = 5.880 + age *(.006) + gender-female (.016) + Black*(-.062) + HZ SW* (.086) + Outer Duval (.027)] + Healthcare Service-TM (-.042) + Provider type NP (.008) +Medicaid *(.237).

Chapter Summary

This chapter describes the research results, including the demographics and descriptive statistics, assumption testing, analysis of the research questions, associated hypotheses and summary of findings. The software used for the analyses in this study was IBM SPSS 27. Statistical tests were determined to be statistically significant at a p-value of 0.05.

Frequencies and percentages were reported for categorical variables of the reference group. Means and standard deviation were reported for continuous variables.

RQ1-the number of *patients with uncontrolled diabetes* with unique ID's were 111, the highest numbers and percentages were identified as Black (n = 84, 76%), non-Hispanic (n = 109, 98.2%), females (n = 73, 66%), had the highest number of visits with the NP. The majority of patients resided in the MUA HZs (n = 62, 56%) and the mean age was 54.3, (SD = 11.64) and Medicaid was the most common medical insurer.

RQ2-the number of *patients with prediabetes* with unique ID's were 81, the highest numbers and percentages were identified as Black (n = 54, 67%), non-Hispanic (n = 79, 98%) females (n = 59, 73 %) had the highest number of visits with the NP. The majority of the patients resided in the MUA HZs (n = 52, 64%), and mean age was 58.11, (SD = 12.98) and Medicare was the most common medical insurer.

Patients with uncontrolled diabetes and prediabetes shared comparable traits; they were more likely to be Black, non-Hispanic, females, the median age was 56.9 years, resided in the MUA HZs, and had the majority of visits with the NP.

Patients with uncontrolled diabetes, residing in the MUA HZs had the highest numbers overall for appointment attendance. Patients with uncontrolled diabetes had the highest number of TM appointments (n=986, 56.2%), and F2F visits (n= 964, 48.3%). Patients residing in the MUA HZs had the highest number of visits (51.8%). The number of all patients arriving for appointments was (98.4%).

Assumption tests conducted were Shapiro Wilk to determine if the distributions of the independent variable [Ratio TM/F2F and dependent variables [difference in mean HbA1c values] were significantly different from normality for both research questions. The regression model assumptions evaluated normality, homoscedasticity, and multicollinearity.

The research examined two bivariate linear regression, two bivariate correlation models, and four MLR models for *RQ1* T2DM patients with uncontrolled diabetes and *RQ2* patients with prediabetes to assess the strength of the relationships between multiple predictors/covariates and the dependent variables [difference in mean HbA1c values], and [HbA1c % values], respectively. All covariates were dummy coded if there were more than 2 categories.

The first MLR models analyzed the dependent variable [difference in mean HbA1c values], and the effects of the primary predictor ratio TM/F2F and covariates: age, gender, race, and HZs. The second MLR models analyzed the dependent variable [HbA1c %], and the seven covariates were [age, gender, race, HZs, provider type, medical insurer, and healthcare service type]. Several patients had visits with multiple providers and had more than one medical insurer throughout the study period, excluding the capacity to aggregate or quantify the data for provider type, medical insurance, and healthcare service types variables in the RQ1 and RQ2 analyses.

RQ1 statistical analyses results

Research question 1 asked– Is there an association between the ratio of healthcare service visits via TM-to-traditional mode of care and the difference in mean HbA1c values for TM-to-traditional office visits in T2DM patients with uncontrolled diabetes (=>8.0%), during the study period from January 1st, 2019, to June 30th, 2021.

The analyses of the bivariate correlation table 4.5 and bivariate linear regression models table 4.6 showed significant results $p = .034$ for RQ1. A correlation and a linear relationship was found between the difference in mean HbA1c values and the ratio TM/F2F. Therefore, the null hypothesis H_0 was rejected, concluding there is a significant association between the [ratio TM/F2F visits and the difference in mean HbA1c values in T2DM patients with uncontrolled diabetes.

The analysis of the first MLR model conducted for the *RQ1 study specific variables* table 4.7 in *patients with uncontrolled diabetes* results were not significant, $F(6,104) = 1.197$,

p = .135, R^2 = .088) indicating that the primary predictor [ratio TM/F2F, and covariates [age, race, gender and HZs] did not explain a significant proportion of variation in the difference in mean HbA1c. However, after controlling for the covariates in this model the ratio TM/F2F (B = -.086, p = .036) was significant, suggesting that the ratio TM-to-traditional visits had an inverse correlation with an 8.6% lower difference in mean HbA1c % values.

The results of the second MLR model for *patients with uncontrolled diabetes visits*, table 4.8 were significant $F(8,1676) = 25.781$ $p < .000$, $R^2 = .110$, indicating that approximately 11% of the variance in HbA1c values is explainable by [age, gender, race, provider type, healthcare service, medical insurer, and HZs]. The R^2 for the overall model was 11%. The healthcare service type TM was significant, B = -.339, $p < .000$ after controlling for the covariates in this model, results suggest that TM appointments on average more likely had 33.9 % lower HbA1c % values when compared to F2F visits.

The second MLR model for *patients with uncontrolled diabetes visits*, table 4.8. indicates there is a significant *negative* association between [HbA1c % values] and covariates [age, healthcare service type TM, medical insurer-Medicaid, and the HZ Outer Duval County]. The covariates [gender-female, race-Black, and HZ Southwest] had a significant *positive* association with HbA1c % values. The provider type was not statistically significant.

RQ2 statistical analyses results

Research question 2 asked– Is there an association between the ratio of healthcare service visits via TM-to-traditional mode of care and the difference in mean HbA1c values for TM-to-traditional office visits in patients with prediabetes (=>5.7% – 6.8%), during the study period from January 1st, 2019 to June 30th, 2021?

The analyses of the bivariate correlation table 4.9 and bivariate linear regression model 4.10 were conducted for *RQ2 study variables* for the difference in mean HbA1c values and TM/F2F the results were not significant, $F(1,79)$, $p = .453$, $R^2 = -.005$. The null hypothesis H_0 was not rejected indicating there is NO association between the [ratio of TM-to-traditional office visits] and the [difference in mean HbA1c values] for TM-to-traditional care visits in patients with prediabetes.

Regression model synopses

The analyses of the bivariate correlation and bivariate linear regression models for the *study specific variables* RQ1 of *patients with uncontrolled diabetes* results were statistically significant $p = .034$. A correlation and a linear relationship was found between the difference in mean HbA1c values and the ratio TM/F2F.

The results of the first MLR model for RQ1 *study specific variables* were not significant, $F(6,104) = 1.197$, $p = .135$, $R^2 = .088$) indicating that the primary predictor [ratio TM/F2F and covariates [age, race, gender and HZs] did not explain a significant proportion of variation in the difference in mean HbA1c. However, after controlling for the covariates in this model the primary predictor ratio TM/F2F (B = -.086, $p = .036$) was significant, suggesting that the ratio TM-to-traditional visits had an inverse correlation with an 8.6% lower difference in mean HbA1c % values.

The results of the second MLR model for *patients with uncontrolled diabetes visits* were significant $p < .000$, indicating that approximately 11% of the variance in HbA1c values was explainable by [age, gender, race, provider type, healthcare service, medical insurer, and HZs].

The analyses of the bivariate correlation and bivariate linear regression model for the *study specific variables RQ2* of *patients with prediabetes*, the difference in mean HbA1c values and TM/F2F the results were not statistically significant p = .453.

The results of the first MLR model for *RQ2 study specific variables* were not significant p = .503, indicating that the primary predictor [ratio TM/F2F, and covariates [age, race, gender and HZs] did not explain a significant proportion of the variation in difference in mean HbA1c values.

The results of the second MLR model for *patients with prediabetes visits* were significant p < .000. The R^2 for the overall model reports an effect size 10%, indicating that approximately 10% of the variance in HbA1c % values was explainable by covariates, [age, gender, race, provider type, HZs- (SW, Outer Duval), TM, and medical insurer–Medicaid].

CHAPTER V

DISCUSSION

This chapter includes the research overview, interpretation of the findings, recommendation for future research and practice, strengths, limitations, biases, and conclusion.

The study's primary objective was on T2DM patients with uncontrolled diabetes and prediabetes who utilized TM comparing F2F visits for managing diabetes, with the focus on populations living in UMUPAs.

Research questions asked–Is there an association between the ratio of healthcare service visits via TM-to-traditional mode of care and the difference in mean HbA1c values for TM-to-traditional office visits in patients with uncontrolled diabetes HbA1c (=>8.0%), and prediabetes (=>5.7% – 6.8%), during the study period from January 1st, 2019 to June 30th, 2021?

The study analyzes the mean HbA1c values for patients with uncontrolled diabetes and prediabetes using retrospective data from patients' EHR at the UF Commonwealth Family Medicine Clinic (CFMC). PCPs use HbA1c values to measure glycemic control for diagnostic purposes and to develop treatment plans for diabetes management.[50] Achieving optimal glycemic control by managing HbA1c values is critical for persons with diabetes to reduce potential micro and macrovascular complications.[49] While current TM technology research demonstrates improvements in disease management,[51] more studies are needed to assess the long-term feasibility of healthcare access for populations residing in UMUPAs.[52–54]

The study's underlying context is to analyze viable alternative modes of healthcare services for diabetes management among marginalized populations who reside in MUAs. Populations living in MUA/UMUPAs face significant personal and systemic barriers in obtaining adequate healthcare services. Barriers are extremely problematic for people with chronic illnesses, often leading to complications in disease management and adverse health outcomes.[97]

Before the pandemic, the most frequently utilized healthcare service was the traditional mode of care requiring in-person F2F visits at a provider's office. The mode of care using F2F visits for healthcare services pose significant access challenges for populations living in MUPA/UMUPAs. The elements creating barriers to F2F visits related to SDoH include; unreliable or lack of transportation, physical, mental impairments, financial limitations, an imbalance of provider/patient ratio, geographical location/distance to facilities, scarcity or absence of healthcare facilities, time schedules, and provider caseloads and backlogs often resulting in therapeutic inertia.

Patients affected by SDoH will more likely delay care, miss appointments, or forego treatment entirely due to access barriers[43] resulting in poor disease management leading to adverse health outcomes.[97,161] For people with chronic diseases, therapeutic inertia from missed appointments can mean the difference between receiving life-saving preventive care and early disease detection, or late detection, which has higher rates of morbidity and mortality risks.[20,165]

Fewer missed appointments translates to better patient-provider interactions, which can optimize patient adherence to the treatment plan and medication compliance.[20] TM has been shown to reduce barriers, providing patients with access to healthcare services,[51] especially important for populations living in geographically isolated MUPA/UMUPAs.

The VHA's 21st century digital framework was introduced as the conceptual model for this study, based on a contemporary technological approach to healthcare delivery by addressing systemic and individual level barriers. The research examines the VHA digital framework to assess its feasibility of utilizing TM in diabetes management for improving the health outcomes of similarly challenged civilian populations in MUAs.

Interpretation of the Findings

For the analysis of the variables in the research questions, the original dataset was divided into four groups based on the patient's HbA1c percentage values for uncontrolled diabetes and prediabetes. Two different units of analyses were used for the *individual patient level data* measuring the *difference in mean HbA1c values* and the *patient visits* measuring the *HbA1c % values*.

Research question 1

Research question 1 examined, if there was an association between the ratio of healthcare service visits via TM-to-traditional mode of care and the difference in mean HbA1c values for TM and the mean HbA1c values for F2F visits in *patients with uncontrolled diabetes* (=>8.0%) during the study period from January 1st, 2019 to June 30th, 2021

The results for RQ1 were analyzed using a bivariate linear regression model and multiple linear regression (MLR) models for patients with uncontrolled diabetes. The first MLR models for the *study variables* analyzed the dependent variable [difference in mean HbA1c values] measuring the effects of the primary predictor [TM/F2F] and covariates [age, gender, race, and HZ] for patients with uncontrolled diabetes and prediabetes. The second MLR models for *patient visits* analyzed the dependent variable [HbA1c % values] measuring the effects of the covariates [age, gender, race, HZ, provider type, healthcare service type, and medical insurer].

I. The results of the bivariate linear regression model for RQ1 *patients with uncontrolled diabetes* indicated statistical significance for the study variables ratio TM/F2F and the difference in mean HbA1c values. The difference in mean HbA1c values and the ratio TM/F2F were correlated and had an inverse linear relationship, suggesting that a higher ratio of TM to F2F visits was correlated with lower difference in mean HbA1c values. The higher number of the ratio TM/F2F ratio, the greater the number of TM visits. The results suggested that TM appointments compared to F2F visits more likely have a 7.4% lower difference in mean HbA1c value therefore the null hypothesis H_0 for RQ1 was rejected.

II. The analysis of the results for the first MLR model for RQ1 *study variables* in T2DM *patients with uncontrolled diabetes* were not statistically significant, for the difference in mean HbA1c values and age, gender, race, and HZs. Although the *p*-value for the overall model was not significant, after controlling for the other covariates, the ratio TM/F2F was significant, suggesting that the ratio TM/F2F visits had an inverse correlation with an 8.6% lower difference in mean HbA1c % value.

III. The second MLR model for *patients with uncontrolled diabetes visits* indicated there was a significant association (p = .000) between [HbA1c % values] and the seven predictors [age, gender,race, HZs, healthcare service, medical insurance, and the provider type.

Research question 2

Research question 2 examined if there was an association between the [ratio of healthcare service visits] via TM-to-traditional mode of care and the [difference in mean HbA1c values] for TM visits-to-traditional care visits in patients with prediabetes (>=5.7–6.8%) during the study period from January 1st, 2019 to June 30th, 2021.

IV. The analysis of the results of the bivariate linear regression and bivariate correlation models for the RQ2 *study variables* in *patients with prediabetes* indicated there was not a significant association (p = .227) between the [difference in mean HbA1c values] and the ratio TM/F2F. Therefore, the null hypothesis was not rejected H_0 for RQ2–there is NO association between the ratio TM/F2F and the difference in mean HbA1c values for ratio TM/F2F visits in patients with prediabetes (>=5.7–6.8%).

V. The results of the first MLR model RQ2 for *patients with prediabetes* were not significant ($p = .503$) indicating ratio TM/F2F, age, gender, race, and HZs) did not explain a significant proportion of variation in difference in mean HbA1c values.

VI. The second MLR model for *patients with prediabetes visits* examining HbA1c values was significant ($p < .000$) The predictor variables that indicated statistical significance were age, race–Black, HZ SW, and medical insurer–Medicaid. The predictors that were not statistically significant were gender, healthcare service type, provider type, and the HZ Outer Duval County.

The bivariate correlation, bivariate linear regression, and the MLR models for the RQ2 study variables for *patients with prediabetes* were not statistical significance.

Summary of Findings

Reflection and main findings from research

RQ1: The bivariate regression and correlation model for RQ1 concluded there was a significant correlation and linear association between the [ratio TM/F2F] and the [difference in mean HbA1c values].

The literature review examined studies of patients with T2DM across heterogenous populations that evaluated the effectiveness of TM to traditional F2F visits for diabetes management and HbA1c values. The search included the Journal of Medical Internet Research, the World Journal of Diabetes, and the Informatics for Diabetes Education and Telemedicine (IDEATel), that indexed comprehensive, archival studies published over several years. The studies examined multiple SRs, MAs, RCTs, and qualitative investigations from various geographical regions, countries, and time periods. These investigations reported that TM is comparable to traditional visits in terms of its effectiveness in reduced HbA1c values in patients with T2DM.[102]

The Journal of Medical Internet Research, in 2021, conducted a twelve year (2008–2020) comprehensive systematic literature search on the effectiveness of TM interventions for managing T2DM. The study focused on TM communications between healthcare providers and patients. The interventions included; (synchronous–audio/video, asynchronous–email, text messaging, internet/web-based platforms in diabetes management and glycemic control.[101] The literature search included a total of 99 studies, 82,000 cases, 16,000 patients and 7 countries with the results reporting the mean HbA1c decrease of -1.15% with an average HbA1c value of 6.95%.[101]

The World Journal of Diabetes, conducted a review in 2021 of 43 MAs synthesizing RCTs of 31 years (1989-2020), reported a significant reduction of HbA1c values (-0.486%) by extracting data from the difference in mean HbA1c values and SD. [102]

Long-term RCTs for TM case management undertaken by the Informatics for Diabetes Education and Telemedicine (IDEATel), found that patients maintained improvement in HbA1c values of 0.29%, for over five years.[93] The IDEATel study population were adults over 55 years, ethnically diverse (African- American and Hispanic), fluent in English or Spanish, Medicare beneficiaries with T2DM, reside in federally designated MUAs or Health Professional Shortage Areas (HPSA) of New York State.[93]

At the time this research was conducted there were limited studies based in the US that compared the efficacy of TM/F2F visits in diabetes management and HbA1c values. This study was distinct in several ways; a retrospective, quantitative study design and regression models were used to capture unique, real-time, PHR data. The study uniquely analyzed the health records of patients with prediabetes and uncontrolled T2DM, who resided in an UMUPA, had visits in one medical clinic, and were high utilizers of TM technology. The study compared patients' use of TM and F2F visits with the mean HbA1c% values. The research demographic has unique characteristics, with one of the highest rates of chronic disease, hospitalizations, and ER visits related to diabetes in the state of Florida.

Although there were no comparable studies at the time this research was authored the final study results were consistent with previous studies. The results found a significant association between the utilization of TM compared with traditional visits and lower HbA1c% values in patients with T2DM, suggesting that TM is an effective diabetes management tool.[74,90,108,109]

When diabetes is managed, it offsets future complications related to uncontrolled HbA1c values. Reductions in the HbA1c values are significant and can mitigate diabetes-related deaths and microvascular complications in patients with T2DM. A seminal study conducted by the UK prospective diabetes observational study (UKPDS) analyzed data from 23 hospital clinics in three countries (England, Scotland, and Northern Ireland), showed that a 1% reduction in mean HbA1c is associated with a 21% reduction in diabetes-related deaths, and a 37% reduction in microvascular complications in T2DM patients.[106]

RQ2: The bivariate correlation, bivariate regression, and the first MLR model for RQ2 patients with prediabetes analyzing the difference in mean HbA1c values were not statistically significant. It is important to note, that patients with prediabetes who maintain regulated HbA1c values demonstrate successful glycemic management.

The results for the second MLR model for patients with prediabetes investigating the HbA1c % values and the effects of the covariates [age, race, HZs, and medical insurer] were statistically significant. The results reported Black adults patients with prediabetes were more likely to have 6.2% lower HbA1c values than White patients. Patients in HZ SW had significantly higher HbA1c values of 8.6% compared to patients in the MUA HZ. Patients in HZ SW have the second highest minority population in Duval County. These findings were noteworthy especially considering the generalized statistics that Black patients often have higher HbA1c values than Whites. The lower HbA1c values of Black patients in the MUA HZ may be due to higher patient engagement reported by the number of healthcare visits compared to patients in the HZSW.

Mixed methods research may disclose important details by identifying relevant confounders that include personal, social and environmental conditions that are influential factors contributing to patients' HbA1c values, rather than technology. Future researchers may find it useful to use a qualitative research design that incorporates Prochaska's transtheoretical stages of change[193] to examine patients' readiness for change, self-efficacy, social support, and intrinsic motivational factors.

At the time this research was conducted patients with prediabetes, managing HbA1c values as endpoints, and TM utilization was not examined in previous literature reviews, therefore no comparison studies exist. The scarcity of research on patients with prediabetes highlights the critical need for additional studies in this popualtion.

Prediabetes effects approximately 96 million Americans, or one-third of the US population, and more than 80% are unaware of having it.[135] Unmanaged prediabetes is shown as a precursor for higher HbA1c values which leads to T2DM, and a higher risk for stroke, and heart disease.[136] The American Heart Association (AHA) recently reported that the development of HF in patients newly diagnosed with T2DM is associated with the highest five year risk of death.[194,195]

The study evaluated patients at the extreme ends of the diabetes spectrum, examining the earliest development of diabetes (prediabetes) to the latent (uncontrolled diabetes) stage, to assess the efficacy of utilizing TM compared with F2F visits in diabetes care, specifically analyzing changes in the HbA1c % value. Patients with prediabetes and uncontrolled diabetes are at a critical juncture in terms of clinical outcomes. Providing timely prevention and intervention methods is essential in halting the progression of elevated glycemic levels, thus lowering the potential for developing complications.

One of the HP2030, LHI goals prioritizes risk-reduction strategies to decrease the prevalence of diabetes and improve population health and overall QoL[59,132] Hence, this study is relevant as the first to examine HbA1c values in patients with prediabetes. The need for further research and the development of comprehensive prevention-based strategies is essential to decrease the prevalence of T2DM.

Patient compliance rates and completed appointments

A recent 2021 study published in the Annals of Medicine found a strong association between TM and fewer missed appointments when compared to F2F visits, particularly among patients with chronic conditions, mental health issues, and those living in urban/metropolitan areas.[20] Patients who frequently missed appointments cost the US approximately $50 billion per year, and generally have poorer health outcomes, which is especially problematic for patients with chronic illnesses.[20] Patients completing healthcare appointments is indicative of higher rates of patient engagement leading to greater adherence to the treatment protocol.[20]

This study looked at the CFMC patients' compliance rates for completing appointments. The CFMC had a high rate of appointment completions (98.4% arrived, 1.6% missed), using both TM and F2F visits, allowing for more intensive, consistent case management. The high rates of appointment completions may suggest that integrating TM and F2F visits contributes to convenient access to healthcare services [13] and a factor in facilitating compliance with treatment protocol. Although these findings shouldn't be interpreted as causal factors, they may stimulate further research.

Digital literacy and TM utilization

A Stats Brief presented to the U.S. Department of Education defines digital literacy as "digital problem solving," understanding how to access and utilize e-mail, obtaining web-based health information, and managing personal information online.[119] To effectively utilize TM technology, one must acquire digital literacy. The 2018 Stats Brief, reported adults who are not digitally literate are more likely to be less educated, older, Black, Hispanic, or born abroad, and tend to work in lower skilled jobs. Black adults who are not digitally literate (22%) is twice that of White adults (11%).[119]

Despite the fact that the CFMC's population is demographically categorized as having a higher percentage of digital illiteracy, they were recognized as the "technologically mitigated clinic" among all of the UF CHFM clinics, successfully enrolled 95% of the patients on the electronic patient health portal. Patients with uncontrolled diabetes, living in an UMUPA had the highest percentage of TM utilization among the entire CFMC study population. The patients identified as predominantly Black, females, < 60 years of age, lived in HZ1, the Urban Core, one of Jacksonville's lower SES communities with lower educational literacy skills, displayed technological capabilities in the utilization of TM for healthcare needs.

Data collection challenges

A third party conducted the data extraction from patient's EHRs. Because the original data was retrospective over (two and a half years), and not previously collected for research purposes, it required an extensive process and considerable time to identify the specific variables required for research. To ensure internal validity and quality of the data obtained, several IDR analysts closely monitored the entire process for over 3 months. The highly complex and rigorous data extraction included creating unique patient identification numbers, deciphering numerous medical codes from providers, thorough case matching by service dates, lab test results, service types, and demographics.

The final results yielded four datasets (two uncontrolled and two prediabetes) that included datasets with one unique patient ID, and aggregated visit dates, mean HbA1c lab values, and healthcare service visits (TM or F2F).

VHA Conceptual Framework

The VHA's 21st century digital framework served as the underpinnings for the study using technology potentially providing an alternative healthcare access modality among geographically isolated populations in MUPA/UMUPAs. The VHA are pioneers employing TM to meet the healthcare requirements of geographically isolated veterans with chronic illnesses.

The VHA's 21st century framework was selected for; its relevance in the current digital era; the success achieved caring for the unhoused veteran population; and the potential for future expansion to similarly vulnerable populations suffering from chronic illnesses with healthcare access challenges.

A 2019 study based on Medical Expenditure Panel Survey (MEPS) data found that the veteran patient population have similar health risk factors as civilians–mental and physical disabilities, multiple co-morbidities, and chronic health disorders.[178,179] Other similar challenges include lower SES, high unemployment rates, limited transportation, limited financial resources, living in MUPA/UMUPAs, reduced number of service providers, geographical constraints, and the inability to schedule timely appointments.

The VHA redesigned the Penchansky and Thomas' model, [48] as a more germane framework suited for the 21st century digital/technological era [61] addressing veteran's healthcare access challenges. The Penchansky and Thomas's five dimensions of healthcare access includes–availability, accessibility, acceptability, affordability, and accommodation in service design. The VHA's 21st century framework revised the former healthcare access model based on the degree of "fit" or match between the community, and the healthcare system which incorporated the constructs; geographical, temporal, financial, cultural, and digital.[174]

(1) Geographical- *Accessibility*

The geographical construct includes the commuting distance to the physical location of the healthcare facility, the population's residence, and the availability of transportation. When people live in isolated areas, have limited financial resources, lack medical insurance, and lack adequate transportation the ER becomes their source of healthcare.

(2) Temporal – *Availability*

The temporal construct is the time factor related to the demand and supply of services needed by patients.[47] The temporal dimension is critical for patients receiving timely medical care, thereby mitigating the detrimental impact of therapeutic inertia by delaying and avoiding essential healthcare services.

(3) Financial –*Affordability*

The financial construct of access includes patients' costs related to health services, and healthcare insurance; insurance premiums; eligibility requirements, and out-of-pocket expenses.

(4) Cultural –*Acceptability*

Technology is becoming more adaptable to diverse cultural backgrounds and literacy skills. The cultural construct of access refers to a healthcare provider's ability to convey medical information based on the patients' level of understanding, which encompasses of variety of factors such as; age, gender, language, communication aptitude, educational level, race, ethnicity, background, and cultural norms In order for TM to become standard practice, it is crucial that it is tailored/fitted to the patient's competency level, motivation, and aptitude to use technology.[103]

(5) Digital–*Accommodation*

The digital construct provides 24/7 healthcare access by allowing physicians and patients to communicate via audio/video technology.[180] TM appointments include–digital connectivity; smart phone, remote monitoring devices-camera, speakers, and health applications.

There are many factors that preclude patients from having regular care with a provider these may include; scheduling challenges, wait time for appointments, fear and anxiety in F2F visits, oral communication and mobility challenges, linguistic and cultural barriers, transportation issues, financial expenditures, forgetfulness, and weather conditions.[20]

The systemic, structural, financial, and logistical obstacles that frequently lead people to seek emergency room treatment are generally preventable with improved access to healthcare facilities and routine primary care visits.[91] The goals of TM are to improve healthcare delivery, reduce patient costs, improve accessibility, and expand access to services to marginalized populations by minimizing barriers.

The VHA's digital framework through the use of TM technology may be modified to provide a prevention-focused solution for healthcare access for marginalized populations in overcoming the obstacles associated with F2F visits.

Recommendations for Future Research/Practice

Future research

A mixed methods approach in which a qualitative component is added to this quantitative approach could provide findings that are more applicable to patient care. A non-pandemic environment would allow for a more in-depth view of patient perspectives, such as sharing their experience with technology and details of their healthcare visit. Studies on prediabetes care are critical to gain more information about how TM may serve as a preventative strategy to offset future incidences of T2DM.

Future research may involve a cost benefit analysis comparing TM with traditional visits for patients and clinical providers, as well as measuring the impact on ER utilization and hospitalization rates among diabetes related incidences. Future research may examine TM and missing appointment rates to determine if there is improvement in patient attendance, primarily among people in UMUPAs, which may ultimately improve health outcomes.

Future practice

The study highlights several implications for practice. It is critical to establish positive cross-sectoral collaborative partnerships. Building positive, collaborative teamwork is a mainstay for PH professionals and critical for any population health related project. Healthcare staff are an essential part of the research team in the implementation of TM, providing continuous diabetes education and treatment in their clinic. Healthcare providers that empower patients with the technical knowledge utilizing TM for their healthcare services may find exceptional compliance with patients completing visits, contributing to adherence with prescribed treatment protocol.

Research shows that healthcare providers who actively support and prioritize the success of their patients along with a team-based approach see increased patient engagement, better health outcomes, improved quality measures, decreased time in healthcare delivery compared to traditional office visits.[196]

Healthcare providers require education and support about the benefits of TM for better care delivery, including the time, convenience, and potential financial benefits. Professionals in PH can play a key role in teaching cultural humility and sensitivity to patient navigators and community health workers (CHWs). Patient navigators, CHWs, and PH personnel can conduct outreach programs in areas including senior living facilities, faith based groups, civic organizations, barbershops, and hair salons to teach individuals about the benefits of TM for their healthcare and how to use technology.

The CFMC's utilized a comprehensive case management approach in diabetes treatment demonstrating the viability for expanding this type of practice to other clinics and subsequently decreasing the barriers to healthcare for underserved populations.

Strengths and Limitations

The strengths and limitations of the research are discussed in this section. The results for patients with uncontrolled diabetes and prediabetes should be interpreted with moderation due to confounding circumstances. Patients with diabetes are particularly susceptible to complications from infections and stressors, contributing to additional challenges managing diabetes and may reflect HbA1c fluctuations and abnormal ranges of control due to the pandemic. It is worth noting that managing diabetes during any crisis is extremely difficult, and the effects of the pandemic increases the need and urgency for intensive care.

Strengths

- The results were statistically significant among patients with uncontrolled diabetes, despite the risk factors that may limit intervention effectiveness.
- The 1st study capturing unique real-time data points of patients with prediabetes and uncontrolled diabetes in an UMUPA, examining patients' use of TM and F2F visits in conjunction with mean HbA1c% values.
- Few studies in the US have been conducted demonstrating the effectiveness of TM in diabetes management and its potential to improve healthcare access for vulnerable people.
- This study is especially important for raising awareness of the potential for utilizing interactive, synchronous TM communication as an alternate healthcare delivery method for patient care in high-risk populations with limited healthcare services.
- This clinic developed a novel method of patient care in which the Medical Director employs TM as a non-traditional approach using rigorous case management for diabetes treatment combining TM and F2F care.
- Patients received training and were competent in utilizing TM technology for healthcare services, therefore a large amount of data was available for research purposes.

Limitations and Biases:

- Obtaining retrospective, secondary data that was initially collected for clinical practice made data extraction challenging for research purposes.

- The study design limited the ability to obtain precise data endpoints that reflected changes in HbA1c% values at specific time intervals, which would have allowed providers to track patients' progress.
- The study was unable to account for other factors that may have influenced outcomes, such as lifestyle behavioral changes, availability of healthy food options, physical activity, social support, self-efficacy, relational dynamics, BMI, medications or stress factors.
- The data was collected prior to and during the COVID-19 pandemic, therefore, patients with diabetes are more susceptible to health challenges.
- The distinctive features of the clinic's patient cohort, older, non-Hispanic, Black females, will only be specific to similar populations.
- Selection bias of the clinic as an outlier in utilizing TM, limits generalizability when comparing other clinics.
- Retrospective convenience and purposive sampling limit generalizability only to analogous data types and populations.
- The research design provided inconclusive results for patients with prediabetes.

Summary

The aim of the study was to investigate patients with uncontrolled T2DM diabetes and prediabetes using TM comparing F2F visits for managing diabetes, analyzing HbA1c values taken from retrospective PHRs with the primary focus of patients living in UMUPAs.

The study also found that individuals who used TM and F2F visits were 98 % compliant with completing healthcare service appointments. Patients with uncontrolled diabetes residing in an UMUPA, HZ1, the Urban Core had the highest TM utilization rates for their healthcare service. The results imply that marginalized populations are technologically competent in obtaining healthcare from a modality other than F2F visits.

Healthcare access, health inequities and disparities are recognized as a top priority for PH. [197] Implementing policies to improve healthcare access by mitigating disparity gaps among vulnerable populations is one of PH and healthcare's greatest challenge. Health disparities are projected to worsen in the future as the US population ages and becomes more ethnically and socioeconomically diverse.[198] As our society becomes more dependent on technology, it is essential to identify populations without digital literacy skills to circumvent a broadening of the digital divide and to develop and provide culturally diverse and linguistically appropriate training to individuals lacking these skills.[193]

Personal, implicit biases, and presuppositions about the technical literacy and competency of a population, must be deconstructed through awareness training and education to transcend the health inequity status quo.

Healthcare providers must advance beyond the former gestalts of disease-oriented, tertiary care and implement preventative care solutions, to combat the diabetes epidemic. Therefore, finding alternate, evidence-based, scalable interventions for healthcare service is imperative as a preemptive strategy to address the current and future needs of the population's health and to prevent or delay the onset of diabetes and adverse health consequences.

While there isn't an isolated remedy to fix the deeply entrenched systemic infrastructure problems, this study presents a modified solution for expanding resources to make healthcare services more readily accessible to all populations. The VHA's 21st century TM technology may provide stakeholders with a customizable framework using a systems thinking approach to improve healthcare access where illness and disease pose a significant threat to the health and wellbeing of all marginalized communities. Diabetes treatment necessitates employing a preemptive, intensive case management and a systematic team approach to achieve optimal care for patients.

Conclusions

TM offers a viable, alternative approach for improving and expanding access to care, eliminating geographical barriers particularly for residents in MUAs; with the potential of providing a cost effective, low-resource-intensive, and scalable alternative for healthcare services that is as effective as F2F visits. TM in combination with F2F visits enhances patient compliance, enables providers to monitor patients for more intense interventions, and empowers patients in effectively managing T2DM.[103]

Even though barriers to healthcare access among racial and ethnic populations are well documented in the literature, there is limited evidence of successful interventions that provide practical solutions for people residing in UMUPAs. Despite the study's limitations, this research explored the expansion of TM technology as a potential alternative for prevention-focused diabetes management improving healthcare delivery service to overcome barriers to care for underserved populations. Finally, this research supports PH’s endeavors for tackling the long-standing challenge of healthcare access barriers in underserved communities.[1]

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APPENDICES

APPENDIX A

GSU IRB APPROVAL LETTER

GEORGIA SOUTHERN UNIVERSITY

RESEARCH INTEGRITY

Institutional Review Board (IRB)
Veazey Hall 3000
PO Box 8005 • STATESBORO, GA 30460
Phone: 912-478-5465
Fax: 912-478-0719
IRB@GeorgiaSouthern.edu

To:	Ward, Lisa Ariellah; Shah, Gulzar
From:	Eleanor Haynes, Director, Research Integrity
Approval Date:	10/20/2021
Subject:	Institutional Review Board Exemption Determination - Limited Review

Your proposed research project numbered **H22044** and titled **"Effectiveness of Telemedicine in Diabetes Management: A Retrospective Study in an Urban Medically Underserved Population Area (UMUPA).**
"
involves activities that do not require full approval by the Institutional Review Board (IRB) according to federal guidelines.

According to the Code of Federal Regulations Title 45 Part 46, your research protocol is determined to be exempt from full review under the following exemption category(s):

Exemption 4 Secondary research uses of identifiable private information or identifiable biospecimens, if at least one of the following criteria is met: The identifiable private information or identifiable biospecimens are publicly available; Information, which may include information about biospecimens, is recorded by the investigator in such a manner that the identity of the human subjects cannot readily be ascertained directly or through identifiers linked to the subjects, the investigator does not contact the subjects, and the investigator will not re-identify subjects.

Any data use agreement or agreement change required by the data owner must be supplied to the IRB prior to execution for review. This approval is contingent upon researcher compliance with the conditions of the data use agreement (where required) and current institutional data security policy.

Any alteration in the terms or conditions of your involvement may alter this approval. *Therefore, as authorized in the Federal Policy for the Protection of Human Subjects, I am pleased to notify you that your research, as submitted, is exempt from IRB Review. No further action or IRB oversight is required, as long as the project remains the same. If you alter the project, it is your responsibility to notify the IRB and acquire a new determination of exemption. Because this project was determined to be exempt from further IRB oversight, this project does not require an expiration date.*

APPENDIX B

UF IRB APPROVAL LETTER

UF | Institutional Review Board
UNIVERSITY of FLORIDA

Health Center Institutional Review Board
FWA00005790

PO Box 100173
Gainesville FL 32610-0173
Telephone: (352) 273-9600
Facsimile: (352) 273-9614
Email: irb@ufl.edu

DATE: 10/18/2021
TO: Eric Stewart
CHFM 655 W 8TH ST
JACKSONVILLE , Florida 322096511
FROM: Peter Iafrate, IRB Chairman, University of Florida
Chair IRB-01

IRB#: **IRB202102147**
TITLE: Effectiveness of Telemedicine in Diabetes Management: A Retrospective Study in an Urban Medically Underserved Population Area (UMUPA).

Approved as Exempt

You have received IRB approval to conduct the above-listed research project. Approval of this project was granted on 10/18/2021 by IRB-01. This study is approved as exempt because it poses minimal risk and is approved under the following exempt category/categories:

(4)(iii) Secondary research for which consent is not required: Secondary research uses of identifiable private information or identifiable biospecimens, if at least one of the following criteria is met: (iii) The research involves only information collection and analysis involving the investigator's use of identifiable health information when that use is regulated under 45 CFR parts 160 and 164, subparts A and E, for the purposes of "health care operations" or "research" as those terms are defined at 45 CFR 164.501 or for "public health activities and purposes" as described under 45 CFR 164.512(b)

Approval Includes, but is not limited to:

HIPAA waiver to enroll

Special notes to Investigator (if applicable):

Reviewer Notes: 0 Reviewer Notes

Principal Investigator Responsibilities:

APPENDIX C

VHA 21st CENTURY CONCEPTUAL FRAMEWORK

FIVE HEALTHCARE ACCESS CONSTRUCTS

* (ADAPTED FROM VETERAN'S HEALTH ADMINISTRATION)

Framework Dimensions	Variable	Construct	Description	Definitions
Geographical	covariate	The geographical construct includes "Fit" UMUPA populations.	HealthZones Residential, healthcare facility and providers location.	State; Florida, County; Duval Urban Sub-County; HealthZones; six Healthcare system: UF Health–CFMC
Temporal		The temporal construct timing of appointments.	Flexibility, availability, and scheduling convenience.	Avoidance of therapeutic inertia for healthcare services.
Financial	covariate	The financial construct of access includes ALL costs related to health services.	Out of pocket expenses: medical insurance, travel, loss wages, Rx, Tx and family care.	Insurance type: Medicaid, Medicare, private, self-pay, other
Cultural	covariate	The cultural construct establishes the Fit or suitability between the individual, healthcare system, and the provider.	Culturally and linguistically appropriate for population. Provider cultural sensitivity.	Fit for Race/Ethnicity, age, gender, language, culture, and literacy level.
Healthcare service type	Predictor	TM/F2F office visits.	Synchronous real-time visits.	TM technology and F2F visits.